



Projecting in Space-Time: The Laboratory Method, Modern Architecture and Settlement-Building, 1918-1932.

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**Projecting in Space-time:
The Laboratory Method, Modern Architecture and Settlement-Building, 1918-1932**

A dissertation presented

by

Ivan Rupnik

to

The Ph. D. Program in Architecture, Landscape Architecture and Urban Planning

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Abstract

Between 1918 and 1932, a number of European modern architects described their work as “scientifically managed” or “taylorized”, and as “laboratory work” or “practical experiments”, all of which were approaches attributable to the principles of organization used in American industry. Scholars would later dismiss these claims as “ideological” or “propagandistic”, since many of the architectural works of this period were in fact neither fabricated like industrial products nor did they perform as efficiently. However, relying on recent scholarship regarding the history of American industrial organization between 1880 and 1918, this dissertation reassesses the claims of these architects, revealing a more nuanced and thorough comprehension of the principles of American industrial organization, particularly scientific management, than has been previously acknowledged. While many modern architects admired the tools, products and spaces of industry, a select group also showed interest in scientific management’s central ontological theory, the “laboratory method”, which called for the fusion of inquiry and material production within a single space. While the laboratory method is most closely associated with Frederick Taylor, who developed this approach specifically for use in the industrial plant, it was Frank Gilbreth, who, by 1918, had translated this theory for use in a different space of production, the construction site. Frank and his partner, Lillian Gilbreth, developed a “multi sensory” approach to projecting processes in “space-time”, one that combined orthographic projection with data mapping and new media, such as photography and film. Their “visualization theory” offered modern architects assistance in an already defined design problem, namely the projection of architectural artifacts at the scale of the pre-modern urban unit, the village or settlement, with the intricacy of a pre-modern manufactured product, such as a door or window, all while considering the perception of a moving subject. Utilizing the principles of modern management, architects sought to rationalize their own “mental work”, the production of drawing sets, as well as to participate in the bureaucratization or standardization of material parameters and social conventions, occurring at the municipal, national and international scales, during this period.

While an interest in scientific management among interwar architects was widespread, this dissertation will show that there were few actual examples of the application of these principles to the process of architectural production; the most notable examples were those conducted by Peter Behrens (1918-1920), Le Corbusier (1923-26), Martin Wagner (1924-1929), Walter Gropius (1926-1929) and Ernst May (1926-1930). In all five cases, the primary goals were the same as they had been for Taylor and Gilbreth, the derivation of novel tentative standard methods, and not solely increase in the efficiency of material production. The application of the laboratory method to settlement-building by these architects was not revolutionary so much as it was evolutionary, with Hermann Muthesius' notion of typological evolution and adaptation, summarized in *Kleinhaus und Kleinsiedlung* (1920), as well as a set of projection instruments included in Raymond Unwin's design manual, *Town Planning in Practice* (1909), providing a crucial foundation for the interwar work. This interwar work was further informed by a series of American experiments in industrialized settlement-building, including the Atterbury, Harms and Small, and Unit Systems.

The laboratory method and visualization theory of scientific management required a particular balance of control and feedback, which proved difficult to achieve in architectural production, helping to explain the relatively few applications of these principles. Expanding conjecture from the atelier onto the construction site and into use itself, exposed architects to a myriad of problems that they were not entirely equipped to handle. The unique context of Weimar Germany afforded architects like Wagner, Gropius and May a framework that combined the degree of bureaucratization necessary to support experimentation without the "over-bureaucratization" that would define the postwar period. A similar framework of control and feedback afforded a team of architects, working within in Zagreb, Yugoslavia, between 1957-1964, an opportunity for applying the laboratory method to architectural production. This work would in turn attract the attention of an international group of artists and theorists, the New Tendencies movement (1961-1973), who saw in it the architectural equivalent of "programmed art". As one of the most frequently cited books at these conferences, Norbert Wiener, explained in 1952, "the notion of programing" was itself rooted in the "work of Taylor and the Gilbreths on time study", before it was "transferred to the machine". This research will serve to show that modern architects had translated the principles of industrial organization well before programing became digitized.

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Introduction. Projecting in Space-time

Between 1918 and 1932, a number of European modernist architects, including Peter Behrens, Le Corbusier, Martin Wagner, Walter Gropius and Ernst May, described their own architectural production as having been “scientifically managed” or “Taylorized”.¹ In the canonical histories of modernist architecture, as well as in postwar accounts, these claims have been subsumed under a broader discussion of the relationship of this work to mechanization and industrialization.² In their initial assessment of these claims, architectural historians concluded that the relationship between modernist architecture and Taylorism was primarily an ideological one, in which the “purely technical features” of this system of industrial organization served as a model for social relations outside of the

¹ Peter Behrens (March 1918), Le Corbusier (November 1918), Hermann Muthesius (1920), Martin Wagner (1921), Walter Gropius (1926) and Ernst May (1926) all considered the application of scientific management to architectural practice, with all but Muthesius discussing it in relation to their own work. Mauro Guillen also referenced Max Mayer’s *Die Anregungen Taylors für den Baubetrieb* (1915) as an even earlier discussion, but this is essentially a reproduction of Taylor’s work on concrete mix and curing time studies as well as his discussion of Frank Gilbreth’s bricklaying studies, not a direct consideration of what this might mean for architectural practice, Mauro F. Guillen, *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture* (Princeton: Princeton University Press, 2006), 24-26. Martin Wagner also mentions Taylor and Gilbreth in passing in a brochure, Martin Wagner, *Neubauwirtschaft* (Berlin: Karl Heymann, 1918). He would match the breadth, as well as exceed the depth, of earlier discussions in “Rationalisierter Wohnungsbau,” [Rationalized Dwelling-building.] *Soziale Bauwirtschaft* 5, no. 20 (15 October 1925). Walter Gropius has the last word in this discussion in Walter Gropius, “Erfolge Der Baubetriebsorganisation in Amerika,” *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Technische Tagung in Berlin / 15 bis 17. April 1929 (April 1929). Mary McLeod has pointed out that Le Corbusier mentioned Taylor in every major publication from 1918 until 1933, Mary McLeod, “‘Architecture or Revolution’: Taylorism, Technocracy, and Social Change,” *Art Journal* 43, no. 2 (1983).

² There is no mention of Taylor, Taylorism or scientific management in the canonical histories of the modern movement, including Henry Russell Hitchcock, *Modern Architecture: Romanticism and Reintegration* (1929). Nikolaus Pevsner, *Pioneers of Modern Design: From William Morris to Walter Gropius* (London: Pelican, 1977 (1936)). or Sigfried Giedion, *Space, Time and Architecture* (1960 (1940)). There is also no discussion of this topic in later histories, including Reyner Banham, *Theory and Design in the First Machine Age* (Cambridge: The MIT Press, 1980 (1960)). Leonardo Benevolo, *History of Modern Architecture* (Cambridge: The MIT Press, 1977 (1960)). or Kenneth Frampton, *Modern Architecture: A Critical History*, World of Art (London: Thames & Hudson, 2007 (1980)). Since 1970, Taylor and Taylorism are briefly mentioned by architectural historians, but there has only been one article written specifically on this subject, McLeod, “‘Architecture or Revolution’: Taylorism, Technocracy, and Social Change.”

factory.³ Since this primary analysis, which began in the seventies, culminated in the nineties and has continued to the present day, a more nuanced history of scientific management's formative period, between 1901 and 1917, has been written, articulating the "rather sloppy" use of the term Taylorism.⁴ This new scholarship, occurring outside of the field of architectural history, has paralleled the reassessment of the same period by architectural historians and has provided a much clearer understanding of what motivated modernist architects, starting in 1918, to discuss and apply the principles of scientific management to their ideology and work.⁵

As such, a new definition has been offered to clarify this "set of specific practices" and "general way of viewing the production process"⁶, initially developed, between 1901 and 1917, by Frederick Winslow Taylor (1856-1915) and a group of American engineers,

³ In 1972, Bryan Taylor published a study of Le Corbusier's *Quartiers Modernes Frugès*, in Pessac, near Bordeaux, a project the architect had referred to as his "laboratory of industrialization, standardization and Taylorization", but which the historian concluded the project was "(n)either an efficient, taylorized system of planning nor industrialization of the construction", and that instead "Taylor's concepts figured greatly as ideals", comparable to a "political philosophy" regarding "social and economic development." Bryan Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing* (1972), 18. Bryan Taylor's assessment was cited and further expanded in McLeod, "Architecture or Revolution!: Taylorism, Technocracy, and Social Change." New scholarship on scientific management, not available at the time of these studies, provides a foundation of assessing its use in architectural practice.

⁴ Michael J. Piore, an economist, professor of industrial management at MIT and critic of Taylorized postwar American industry, acknowledged this sloppiness in a review of Daniel Nelson, "Industrial Engineering and the Industrial Enterprise, 1890-1940," in *Coordination and Information: Historical Perspectives on the Organization of Enterprise*, ed. Naomi R. Lamoreaux and Daniel M.G. Raff (Chicago: University of Chicago Press, 1995). That article was the last publication of more than two decades of work by Nelson, who was the first historian to study the application and development of scientific management, between 1901 and 1917. His first article on the subject was "Scientific Management, Systematic Management, and Labor, 1880-1915," *The Business History Review* 48, no. 4 (Winter, 1974). That same year, the seminal and most cited work on the earlier definition of Taylorism, one that informed scholarship well into the nineties was also published: Harry Braverman, *Labor and Monopoly Capital: The Degredation of Work in the Twentieth Century* (New York: Monthly Review Press, 1998 (1974)).

⁵ Stanford Anderson, *Peter Behrens and a New Architecture for the Twentieth Century* (Cambridge: The MIT Press, 2000). Frederic Schwartz, *The Werkbund: Design Theory and Mass Culture before the First World War* (New Haven: Yale University Press, 1996). Allen Brooks, *Le Corbusier's Formative Years* (University of Chicago Press 1999). Wolfgang Voigt Claudia Quirling, Peter Cachola Schmal, Eckhard Herrel, ed. *Ernst May: 1886-1970* (Munich: Prestel, 2011).

⁶ Nelson, "Industrial Engineering and the Industrial Enterprise, 1890-1940."

referred to as the Taylor Circle⁷. Whereas earlier definitions of scientific management, or Taylorism, were constructed by linking the characteristics of postwar production with statements made by Taylor during the last years of his life,⁸ this more recent scholarship has analyzed its founding goal to offer a “comprehensive answer to the problems of factory coordination”⁹. Rather than relying solely on the many articles and manuals produced by the individuals of the Taylor Circle, this new scholarship is based on the study of their actual *installation* of this particular approach to industrial production, conducted during the same period. This research has concluded that much of ‘Taylorism’, including the emphasis on mechanization, specialization and division of labor, as well as incentive wage schemes, was part of an existing form of industrial organization known as “systematic management”, already practiced in American industry around 1900.¹⁰ Consequently, many of the more authoritarian and alienating characteristics associated with Taylorism that developed during the postwar period, cannot be attributed to Taylor, the Taylor Circle or their writings.

⁷ Horace Drury, in an early dissertation on scientific management (1915), listed Taylor, Henry Gantt, Carl Barth, H. K. Hathaway, Morris Cooke, Bertrand Thompson, Harrington Emerson and Frank Gilbreth as members of the Taylor Circle. Nelson also listed the Europeans most influential to spreading Taylor’s approach, with Henri Le Châtelier, “unquestionably the most important ... of the European pioneers”, along with Charles de Freminville, being most active in France. In Germany, Taylor received the approval the Association of German Engineers as early as 1901. Georg Schlesinger, and a two members of the *Allgemeine Elektrizitäts-Gesellschaft* (AEG), Walther Rathenau, the firm’s head and Wichard von Moellendorf, helped spread scientific management into German government. Frank Gilbreth also consulted for *Auergesellschaft* in Berlin and Carl Zeiss in Jena, between 1914-15, the only member of the Taylor Circle to consult in Europe.

⁸ David Nelson, "Introduction," in *A Mental Revolution: Scientific Management since Taylor* ed. David Nelson (Columbus: Ohio State University Press, 1992).

⁹ Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915."

¹⁰ Systematic management was first developed by American railroad trusts, starting around 1850, and already applied to some factories by 1880, when Taylor began his apprenticeship in Philadelphia. Ibid. For a more detailed book-length study of Jo Anne Yates, *Control through Communication: The Rise of System in American Management* (Johns Hopkins Press, 1989). Most examples of Taylorism or scientific management were in fact examples of systematic management. Scientific management was restricted to a few industries, dedicated to long term, costly research and development, like the AEG or Du Pont. For an analysis of Du Pont see John C. Rumm, "Scientific Management and Industrial Engineering at Dupont," in *A Mental Revolution: Scientific Management since Taylor*, ed. David Nelson (Columbus: Ohio State University Press, 1992).

Scientific management began as a critique and a refinement of the ontological principles behind systematic management, which favored “rule of thumb” modes of factory coordination. Taylor argued that standard methods, parameters and instruments of production should not be maintained, simply because of custom, nor was the derivation of new standards, “a subject to be theorized over” by engineering departments in Universities, nor “settled by boards of directors sitting in solemn conclave, nor voted upon by trade unions”. Instead, standards needed to be “determined through the slow and difficult process of trial and error”, within the particular space of production whose operation they would help manage.¹¹ This process of experimental standard derivation, also referred to as ‘time study’, was what Taylor viewed as being “scientific” (1903), and what ultimately led to the use of the term “scientific management”(1910).¹² In order to further distinguish scientific management from the basic elements of systematic management, namely functional foremanship and incentive wage schemes, practitioners invented yet another set of terms to describe this new methodology, including the “experimental method” (1914), the “experimental moment”(1929), the “laboratory idea”(1925) and the “laboratory method”(1922).¹³ While linking their approach with

¹¹ It was this ontological approach, and not the wage system itself, that he emphasized in his first article in 1895, “A Piece Rate”, and it was this approach that he sought to explain in his first book-length article, “Shop Management” (1903).

¹² “Modern engineering can almost be called an exact science... Management will be studied as an art.” Frederick Winslow Taylor, “Shop Management,” *Transactions of the American Society of Mechanical Engineers* XXIV(1903): 63. Louis Brandeis (1856-1941) first proposed the term “scientific management” as a name for Taylor’s approach to systematic management, in 1910. Taylor and other members of the Taylor Circle adopted the term in 1911. For more on this see Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (Cambridge, MA: The MIT Press, 1997). The term Taylorism first appeared around this time as well.

¹³ It was Henri Le Châtelier who would give the earliest written explanation of Taylor’s laboratory method, in Henri Louis Le Châtelier, “Le Système Taylor,” *Bulletin de la Société d’Encouragement pour l’Industrie Nationale* 113(March 1914). Aleksei Gastev, scientific management’s primary proponent in the Soviet Union, used the term “experimental moment” in 1929, Lillian Gilbreth discussed her and Frank Gilbreth’s work, as

scientific management, all of these proponents admitted that this was only an approximation of the more controlled conditions of the actual scientific laboratory; direct engagement with the less controlled space of factory production, as well as the more or less regulated space of consumption, was seen as a value, as well as limitation. In theory, the laboratory method, or “the study of all industrial problems ... done in the factory through the method of experimental science as accurately as possible,”¹⁴ was not superior due to increased managerial control, which systematic management has already provided, but rather because it called for increased feedback. While practitioners, including Taylor, often ignored this feedback, or equated *observation* with *experimentation*¹⁵, this inaction was a fault of those practitioners and in clear conflict with the principles of the laboratory method. Conversely, Taylor’s successes, in terms of innovation, economy and social equilibrium can all be attributed to this approach.

As the laboratory method evolved, during the first decade of the twentieth century, it was further broken down into two phases. The first phase, “experimentation”, was more focused on control, initially involving a particular operator and equipment being “withdrawn from the regular work of the shop” to conduct experiments, recorded through

well as that of Taylor as following the “laboratory idea” in 1925, while it was Frank Copley, in his 1922 biography of Taylor who coined the term “laboratory method”.

¹⁴ “L’étude de tous les problèmes industriels peut et doit être faite à l’usine par les méthodes de la science expérimentale la plus précise.” Ibid., 85. For a discussion of Le Châtelier’s role in promoting scientific management in France and in Europe, see David Nelson, ed. *A Mental Revolution: Scientific Management since Taylor* (Columbus: Ohio State University Press, 1992), 18.

¹⁵ Peter Galison has shown a general trend in the sciences and other fields for this confusion of equation of observation for experimentation, also known as Positivism, during the early decades of the twentieth century. Peter Galison, “History, Philosophy, and the Central Metaphor ” *Science in Context* 2(1988). There are numerous examples where Taylor’s laboratory method is used in this manner in practice, giving credibility to personal observations or widely held prejudices, but there are also examples where an approximation of the scientific method also generated substantial results. Theoretically, Taylor was clear in distinguishing between observation and experimentation, just as he was clear that while he sought to apply the experimental method, the factory could never approach the controlled conditions of a scientific lab or even a building science lab, and in fact, this was not the goal.

time study on a new graphic instrument, an instruction card, as a *tentative* standard. The second phase, “standardization”, focused more on feedback with that tentative standard having been returned to the shop floor¹⁶, followed by the sales floor and into use, for further study, tracked with the assistance of another kind of instrument, the “group instruction card”, or “gantt chart”.¹⁷ In addition to the laboratory method itself, the use of these instruments, generated through experimentation and standardization, also serve to identify this approach in modernist architectural practice. While the process of experimentally deriving and further optimizing, or standardizing, a given process theoretically approached the “one best way to do work”, it was maintained as a “tentative standard”, for years or even decades, until such a time that it became convention, in multiple plants.¹⁸ During this extended process of standardization, a tentative standard could be reassessed through the process of closer study or experimentation. It was this process of experimentation and standardization, the pursuit, not the application of a standard, that Taylor and other proponents of this approach presented as *scientific*. Alternatively, Taylor declared that the standards, as well as the organizational activities to

¹⁶ Frank B. Copley, *Frederick W. Taylor: Father of Scientific Management* (New York 1922). David Nelson on Copley Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915."

¹⁷ The gantt chart was first developed by Henry Gantt at Bethlehem Steel, in 1901. Gantt first published the instrument and related project management method in Henry L. Gantt, "A Graphic Daily Balance in Manufacture," *Transactions of the American Society of Mechanical Engineers* XXIV(1903). The definitive text on instruction cards and gantt charts was Frank Bunker Gilbreth, "The Making and Use of Instruction Cards," *Industrial Engineering and the Engineering Digest* 11(May, 1912). Here Gilbreth distinguished between individual and group or gang instruction cards, later called gantt charts.

¹⁸ Gilbreth discussed the tentative nature of the standard in *The Primer of Scientific Management* (New York: Norstrand, 1912). He distinguished the “tentative standard” from the “superstandard”, a standard that had proven valid after years of use in a variety of conditions, in Frank and Lillian Gilbreth, "Superstandards: Their Derivation, Significance and Value," *Bulletin of the Taylor Society* VII, no. 3 (June 1922). While Taylor was less explicit about the contingent nature of standards in his articles, his earlier texts did not contradict these later articles.

which they were applied, were an “art”.¹⁹ In practice, the application of the laboratory method, particularly to industrial plants that lacked the basic principles of systematic management, often came at the expense of immediate economical efficiency or social equilibrium. However, this was not indicative of a failure to install scientific management, just as the achievement of efficiency and equilibrium through the application of already derived standards, did not constitute scientific management, but systematic management. Through the lens of this new scholarship on scientific management, I am better able to comprehend the primary texts of the Taylor Circle regarding the laboratory method, as well as the range of instruments developed to visualize experimentation, standardization and the projection of tentative standards. Furthermore, it has provided a framework from which to better assess the discussion and application of some of these principles by modernist architects during the twenties.

My study of the translation of the principles of scientific management to architectural practice began with a focus on the postwar period, when the industrialization of architectural production, particularly housing delivery, became widespread. I found that while many of the standard instruments and methods used to plan and manage industrialized housing delivery could be traced back to members of the Taylor Circle, there was much less evidence of the laboratory method being practiced by architects, or even the engineers, who managed the majority of these systems, but relied on architects for certain design services, such as floor plan or site plan layouts, following already predetermined

¹⁹ In architecture, the term experimentation is often used to describe a trial, or an *essay* or “attempt”, while in science and engineering, it denotes trial and error, within very controlled conditions, controlled not to prevent error but to ensure that error is clearly identifiable. Standardization in architecture, along with typification, has been seen as the application of an already existing ideal, standard or type, while in fact, in industrial engineering, and particularly in scientific management, it refers to the development of standards, and not only the application of standards, an iterative and more open-ended process.

parameters.²⁰ The general trend of the postwar period that Brenda Danet has called “over-bureaucratization”, denoting a situation where an “organization comes to dominate the environment, or fails to respond to legitimate needs and demands of the environment”, could also be detected in housing delivery.²¹ This research already pointed to the fact that some of the standards I was seeing in postwar practice, such as those used in the Soviet Union, may have been experimentally derived and standardized by European modernist architects during the interwar period, a time when the disciplinary boundaries of industrial management were not as rigidly “standardized”.²²

Scientific management, and particularly the laboratory method, were developed in the context of late American competitive capitalism. Faced with the relationship between ‘Scientific Management and the State’ very late in his life, Frederick Taylor never fully considered how his ideal space of production as laboratory would change as it was regulated (as it was during the interwar period) or planned (as it was during the postwar period) more centrally, by the State.²³ As Lindy Biggs has shown, in her study of the

²⁰ For my research on postwar industrialized housing delivery see Ivan Rupnik, “Building Systems/Building Territory: The Architects Role in Industrialized Housing Delivery,” in *Building Systems: Design Technology and Society* ed. Ryan E. Smith Kiel Moe (London: Routledge Press, 2012). For a comparison of national industrialized housing delivery approaches during the postwar period see Robert T. McCutcheon, “Science, Technology and the State in the Provision of Low-Income Accommodation: The Case of Industrialized House-Building, 1955-77,” *Social Studies of Science* 22, no. 2, Symposium on ‘Failed Innovations’ (1992).

²¹ Mark Beissinger used this concept to explain the evolution and transformation of scientific management within the context of the Soviet Union’s planned economy. Embraced by Lenin, during the NEP period, and banned by Josef Stalin during the thirties, aspects of scientific management were reintroduced into Soviet industry by Nikita Khrushchev during the postwar period. The term proved useful when other terms, such as bureaucratization and Taylorization would have made little sense, since it was the “over – bureaucratization” that was the subject of the study. Mark R. Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power* (London: Harvard University Press, 1988).

²² “With many managerial jobs being standardized, the person who standardized them, whose job was not yet standardized – the industrial engineer – experienced enhanced status.” Lindy Biggs, *The Rational Factory: Architecture, Technology, and Work in America’s Age of Mass Production* (Baltimore: Johns Hopkins University Press, 1996).

²³ The specific phrase ‘Scientific Management and the State’ was the title of the section of Sidney Webb and Arnold James Freeman, *Great Britain after the War* (London: George Allen and Unwin, September, 1916). Gilbreth used the exact same phrase, only in German, for the conclusion of Frank B. Gilbreth, *Das Abc Der*

development of the 'rational factory', during the early interwar period, industrial engineers in America enjoyed the privileged position of defining the roles of other disciplines in relation to industrial production, before their own role was thoroughly defined and regulated, by the end of the interwar period.²⁴ The existing division of labor and professional specialization of the architectural and engineering professions in America, where scientific management originated, or in France, where it was first presented, in 1900 in Europe, may also suggest why it was predominately German, and German-trained, architects, that showed the greatest interest in scientific management, reflecting another important and unique feature of Germany's particular attitude toward the regulation of industrial production, which emerged at the national scale starting in 1917.²⁵ That year, in line with Taylor's principles, German engineers organized a program that scaled up the laboratory method from the space of an individual plant or an industry, to that of the

Wissenschaftlichen Betriebsführung, trans. Colin Ross (Berlin: Julius Springer, 1921 (1917)). Henry Gantt devoted much of his last book to this subject, Henry L. Gantt, *Organizing for Work* (New York: Harcourt, Brace and Howe, 1919). While Taylor concluded *Principles* (1911), with a discussion of the broad applicability of his approach to other fields, including public administration, he was referring more to the organization of clerical work, than of the question of how government regulation and industrial standardization would relate in the future. The closest he came to addressing this issue was as in relation to the Congressional investigation of his approach in 1910. For more on this see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*.

²⁴ Biggs, *The Rational Factory: Architecture, Technology, and Work in America's Age of Mass Production*.

²⁵ For more on this see Mauro F. Guillen, *Models of Management: Work, Authority and Organization in a Comparative Perspective* (Chicago: The University of Chicago Press, 1994). Also *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture*. Nelson also deals with this issue in Nelson, "Introduction." Faced with the relationship between 'Scientific Management and the State' very late in his life, Frederick Taylor never fully considered how his ideal space of production as laboratory would change as it was regulated (as it was during the interwar period) or planned (as it was during the postwar period) more centrally, by the State. Antoine Picon's history of the professional institutionalization of architecture and engineering in France, provides a useful background for understanding these differences, Antoine Picon, *French Architects and Engineers in the Age of the Enlightenment* (Cambridge: Cambridge University Press, 1992 (1998)). Hynungmin Pai also considers this subject, in the American context, in Hynungmin Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America* (Cambridge: The MIT Press, 2000).

nation, called the *Standardization Committee of German Industry* (NADI).²⁶ While tentative standards would still first be experimentally derived and standardized within the space of an individual plant, interdisciplinary teams would now solicit and analyze those standards, in order to prepare national tentative standards, or DI-Norms, for voluntary use by other industries and as potential references for compulsory regulations.²⁷ With the development of an ancillary program to NADI, *The National Research Association for the Systematization of Building and Dwelling Methods* (RFG), the laboratory method was not only possible in Germany, between 1926 and 1930, but it was supported, through a program of “experimental settlements”, spaces of production and consumption, managed by leading modernist architects.

The two most important “experimental settlements”, the Törten Siedlung (1926-1929), managed by Walter Gropius, and the Praunheim Siedlung (1926-1930), managed by Ernst May, constitute the most thorough application of the laboratory method and the instruments of visualization and projection developed to assist in its execution. Two earlier periods of partial application of the principles of scientific management directly informed this work, the first including a series of projects by American practitioners, between 1909 and 1918, and a second set managed by European modernist architects, between 1918 and 1926. The earliest potential application was managed by Grosvenor Atterbury, as part of his work for the Russell Sage Foundation at Forest Hills Gardens, between 1909 and 1918.

²⁶ The *Verein Deutscher Ingenieure* (VDI), the German engineer society, lobbied for the formation of the *Normenausschuß der deutschen Industrie* (NADI), or “Standardization Committee of German Industry”, in 1917. The committee changed its name in 1926 to the *Deutscher Normenausschuß* (DNA), or “German Standardization Committee”, reflecting its expansion out of the factory. The non-governmental agency collected tentative standards from various industries, before issuing standards that might apply to multiple industries, called DI-Norms, short for German Industrial Norms.

²⁷ Peter Behrens (1919), Hermann Muthesius (1920), and Frank Gilbreth, a member of the Taylor Circle (1922), all equally admired the NADI program for similar reasons. The same qualities admired during the twenties are still evident in the organization today. For more on this see din.de.

Atterbury's work applied the laboratory method to the refinement of prefabricated concrete panel fabrication and assembly, but a number of factors, including the architect's own training and the division of labor between him and the settlement designer, Frederick Law Olmstead Jr., limited its application.²⁸ The second American application was the Harms and Small System of site cast concrete housing, developed by two American engineers, Henry Harms and George Small, using the laboratory method, as well as a number of specific instruments and practices attributable to the work of Frank Gilbreth. This system was developed through a series of collaborations with architects in Holland in 1912, where the unit logic was experimentally derived, and in France, from 1913-1916, where the unit and settlement logic was further standardized in collaboration with French architects.²⁹ The final, and most directly influential American application was the Unit System, developed and patented by John Conzelman, an engineer with extensive experience in precast factory and transportation infrastructure, who first applied the system to the planning, fabrication and construction of a worker's settlement in Ohio, between 1917-19,

²⁸ The most thorough discussion of Atterbury's work today is included in Peter Pennoyer and Anne Walker, *The Architecture of Grosvenor Atterbury* (New York: W W Norton & Co., 2009). Atterbury's own texts on his intentions and his conclusions are Grosvenor Atterbury, "Model Towns in America," *Scribner's Magazine* 52 (July 1912). And *The Manufacture of Standardized Houses: A New Industry* (New York: Standardized Housing Corporation, 1918). Atterbury's work was known to Le Corbusier, through Maurice M. Sloan, *The Concrete House and Its Construction* (Philadelphia: The Association of American Portland Cement Manufacturers, 1912). Martin Wagner also included this work in *Soziale Bauwirtschaft und Wohnungswirtschaft*. The division of labor between landscape architect and architect limited the ability to apply the laboratory method. The patronage of the Russell Sage Foundation also allowed Atterbury to ignore the real cost of the highly mechanized fabrication system while also encouraging him to focus primarily on single-family and duplex types.

²⁹ Very little secondary literature exists on the Harms and Small System. The most thorough discussion is included in a foot note in Tom Peters, *Building the 19th Century*: (Cambridge: The MIT Press, 1996). The importance of the two engineers for the history of Dutch modernist architecture is acknowledged briefly in Tjeerd Boersma, *Betondorp: Ontwerp, Maatschappij, Techniek* (1987). The two engineers collaborated with Dutch architects, H. Hana and Hendrik Berlage, on the first reinforced concrete house in that country, in 1912. That house was the first in a series of "experiments" that used the laboratory method and Gilbreth's visualization theory for a single pour site cast concrete system, a significant improvement on Thomas Edison's earlier studies, on which the engineers worked, in 1907-08. Harms and Small found the *zakelijkheid* (Dutch for *Sachlichkeit*) sensibilities of Berlage and Hana in tune with their own aesthetic sensibilities. Their work was widely published in the same magazines that included Atterbury's work, *Concrete* and *Cement Age*.

in collaboration with the architecture and 'town-planning' firm Herding and Boyd.³⁰ In all three cases, the laboratory method was applied to the fabrication and construction of these projects, but the experimentally derived standards only partially informed the work of the architects involved in the unit and settlement designs.

Starting in 1918, European modernist architects began to consider how the laboratory method might be more directly applied to the *conception of houses in series*, and not only their *mass production*. The earliest modernist architect to discuss the laboratory method in relation to his own design work was Peter Behrens, in 1918. Martin Wagner was the first European modernist architect to apply standards, experimentally derived by a member of the Taylor Circle, Frank Gilbreth, to settlement design, between 1918 and 1919. Additionally, Wagner would discuss and apply the laboratory method to the work in 1925.³¹ The earliest discussion and application of the laboratory method by a European modernist architect, before 1926, was Le Corbusier's "laboratory of industrialization,

³⁰Conzelman is briefly cited in Amy Slaton, *Reinforced Concrete and the Modernization of American Building, 1900-1930* (Pittsburg: Johns Hopkins University Press, 2003). Martin Wagner discussed Conzelman's work in detail in the journals he edited during the twenties. Ernst May singled out the Unit System in Ernst May, "Mechanisierung Des Wohnungsbaues," *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 2(December 1926). Conzelman's lecture on 'ready-made houses' is one of the earliest and more prosaic discussions of industrialized housing delivery, John E. Conzelman, "Ready-Made Houses," in *Proceedings of the Sixth National Conference on Housing: Housing Problems in America* (New York: National Housing Association 1917). Like Atterbury and Harms-Small, his work was published in *Concrete and Cement Age*.

³¹ Wagner, "Rationalisierter Wohnungsbau." In this article, Wagner outlines the work for the DEWOG subsidized GEWOG *Siedlung* in Berlin, which started that year. The GEWOG *Siedlung*, also known as the Hufeisensiedlung Britz, was a clear application of scientific management principles, including the laboratory method and many instruments specifically attributable to Frank Gilbreth. It lacked the ambition of Le Corbusier's earlier work in Bordeaux or the scope, scale and innovation of Gropius and May's "experimental settlements", both which started a year later. Another settlement of this period that is sometimes discussed in relationship to Taylorism or scientific management is Betondorp, in Amsterdam, Holland, between 1923 and 1927. At Betondorp, like in the earlier American examples, there was a much stricter division of labor, between town planning, unit design and building system development. For more on this project see Helen Searing, "Betondorp: Amsterdam's Concrete Garden Suburb," *Assemblage* 3(1987). I will use both projects in comparison to Le Corbusier's work at Bordeaux, between 1923 and 1926, and Gropius and May's work in Germany, between 1926 and 1930.

standardization and Taylorization” at Pessac, actually the third in a series of projects explicitly planned to experimentally derive and standardize methods of housing delivery that began in December 1923. As this project was limited by a lack of political support, the full range of instruments of experimentation and standardization, as well as other factors attributable to the author and his collaborators, this project did not achieve the economic efficiency and social equilibrium it promised. However, like many of Taylor and Gilbreth’s most productive laboratories, it generated a series of highly influential standard methods and instruments, included in Le Corbusier’s later publications.

The third example consists of the “experimental settlements” program, where the core principles of scientific management were most directly applied to architecture. While the RFG subsidized four settlements, including the *Weißenhofsiedlung* in Stuttgart, and the Munich Post Office Siedlung in Munich, it was Gropius’ Törten Siedlung and May’s Praunheim Siedlung, that would apply the laboratory method to every aspect of settlement *delivery*.³² These “experimental settlements” exceeded the ambitions of the Taylor Circle by not only experimentally deriving standards for a particular company, industry or profession but by generating national norms.³³ Further study of the industrialized housing delivery standards produced by Ernst May for the Soviet Union, in 1932, will demonstrate the lack of architect involvement and application of the laboratory method in industrialized housing delivery during the postwar period, on both sides of the Iron Curtain.

³² By delivery I mean the full range of activities involved in producing a settlement, including financing, construction, design as well as post occupancy assessments.

³³ The RFG is short for *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen*, or the “The National Research Association for the Systematization of Building and Dwelling Methods”. The most thorough history of the RFG is included in Andreas Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm* (Dresden: Thelem Universitätsverlag, 2010). This significantly revises earlier histories of this important association included in Barbara Miller Lane, *Architecture and Politics in Germany, 1918-1945* (Cambridge: Harvard University Press, 1968).

Through an analysis of these case studies, I will redefine the relationship of scientific management to that of European modernist architecture. Like the pioneers of scientific management, architects sought to apply these principles to rationalize their own “mental work”,³⁴ in the form of “architectural drawing, ... the main thoroughfare between ideas and things... the principal locus of conjecture in architecture”. Architects applied the laboratory method to this process by incorporating and evolving the projection instruments used in industrial engineering to assist in their own experimentation and standardization.³⁵ Orthographic drawings already combined calculation and visualization of static objects and volumes, but now they could do the same for processes. These more powerful instruments of projection, were applied to an existing, but still unconventional, architectural problem, namely the design of artifacts at the scale of a pre-modern urban unit, a village, at the intricacy of a pre-modern craft object, a door or window, and at the resolution of a pre-modern architectural commission, a villa or a public building: the *Siedlung*, or settlement.³⁶ For some architects, the laboratory method provided a way of extending the process of *conjecture*, from their own “mental space” or that of the atelier, into the “social space”³⁷ of the construction site, where the “translation from drawing to

³⁴ Le Corbusier 1918, Peter Behrens 1918, Hermann Muthesius 1920, Martin Wagner 1924, Wilhelm Lübbert 1926, Walter Gropius 1926-29, Ernst May 1926-29, all emphasize the importance of scientific management to managing their mental work, as well as their drawings being used in the mental work of others.

³⁵ Robin Evans, "Architectural Projection," in *Architecture and Its Image: Four Centuries of Architectural Representations*, ed. Eve Blau and Edward Kaufman (Montreal: Canadian Centre for Architecture, 1989).

³⁶ By pre-modern, architects usually referred to before the early or mid 19th century. Vernacular buildings, urban landscapes and craft products remained an ideal and were often cited and compared to the industrial vernacular.

³⁷ Henri Lefebvre, *The Production of Space*, trans. Donald Nicholson-Smith (Oxford: Blackwell, 1991 (1974)). For Lefebvre, modern society has stifled the process of language and meaning production, by over-regulating culture, something he sees reflected in the theories of structuralist and poststructuralist linguistics. His use of the terms “mental space” and “social space” are used to aid in this critique. Within their own disciplines, industrial engineers and architects looked to the laboratory method to facilitate a similar extension from their own mental space to the social space of the factory or the building site; while this theory presupposed more control than Lefebvre’s, it could also not survive without feedback generated by some form of social

building”³⁸ took place. Some went even further, engaging in post-occupancy evaluations of their “tools for living”³⁹, extending the process of standardization, from production to occupation. For many, the use of the laboratory method was seen as participating in an even larger-scale design problem, the design of the national regulatory environment, one that engineers were already shaping.⁴⁰

In most of these translations, three individuals played a crucial role as intermediaries between American industrial engineering and European modernist architecture. Within the Taylor Circle, Frank Bunker Gilbreth (1868-1924), a brick-layer turned contractor turned industrial consultant, had already synthesized the more abstract, numerically based, projection instruments developed by Taylor and Gantt with architectural and engineering projection instruments, such as drawings and models, as well

interaction and exchange. In 1969, Lefebvre applied his own theories of “mental” and “social space” to an analysis of Pessac, wondering if the projects capacity for people “to install their daily lives” in Le Corbusier’s “cubes” was intentional, had “Le Corbusier wanted that?”. Philippe Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale* (Paris: Bordas 1985 (1969)).

³⁸ Robin Evans, “Figures, Doors, Passages,” in *Translations from Drawing to Building and Other Essays* (London: Architectural Association London, 1997).

³⁹ Le Corbusier used this term in his early discussions of serial housing, shifting to the “machines for living” after 1926.

⁴⁰ Antoine Picon has pointed to the engagement of the engineering disciplines with the State as a decisive factor in their institutionalization in France, during the late 18th and early 19th century, while architecture sought to maintain its own disciplinary autonomy by maintaining a greater distance from the State. Picon also explains how the engineer engaged the “modern landscape” while the formally trained architect retained an interest in the self-contained object. For more on this see Picon, *French Architects and Engineers in the Age of the Enlightenment*. In Germany, the disciplinary boundaries between engineering and architecture remained more porous, with many architects holding the degree, *dipl-ing*. This basic technical expertise was linked with a more active lobbying for the architect as urban planner, most vocally advocated by Camillo Sitte, the Austrian proponent of “city-building artistically considered”. For more on the history of the architects role in city-building see Eve Blau and Monika Platzer, ed. *Shaping the Great City: Modern Architecture in Central Europe 1890-1937* (New York: Prestel, 1999). When working on New Frankfurt, Ernst May brought over a predominantly Viennese crew to assist him. For more on this link see Eve Blau, *The Architecture of Red Vienna, 1919-1934* (Cambridge: The MIT Press, 1999). For a history of the role of the German architect in municipal planning and building regulation see Lane, *Architecture and Politics in Germany, 1918-1945*. Here, earlier Wilhelmine Era housing and urban policies are also discussed. In America and England, engineers and landscape architects, showed much more interest in urban planning, policy and settlement design than architects. For more on this see Margaret Crawford, *Building the Workingman's Paradise: The Design of American Company Towns* Haymarket Series (Baltimore: Verso, 1996). When Raymond Unwin, a trained mining engineering sought to introduce the architect into settlement-design in the Anglo-Saxon speaking world, he turned primarily to Central European examples to support his argument.

as new media, including photography and film, by 1913. Gilbreth's 'visualization theory', specifically designed to assist in the laboratory method, but also applicable as a stand-alone system of projection, was available in France, as early as 1914, and in Germany, as early as 1917.⁴¹ In Continental Europe, Hermann Muthesius (1861-1927) provided an important theoretical framework for this translation through his theories regarding types. Starting around 1901, Muthesius equated vernacular architecture and modern industry as two modes of production that shared a similar process of innovation through an unconscious collective evolution and adaptation.⁴² By 1913 he acknowledged more consciousness and "artistic sensibility" in the modern engineers' pursuit of form.⁴³ By 1920 he finally identified the principles informing this pursuit, "scientific management", which had already been partially translated for building, by Frank Gilbreth. In this text he also addressed a new technological and social revolution, the "control revolution"⁴⁴, which was rapidly translating the previously negotiable social and tectonic conventions that architects had

⁴¹ Gilbreth's projection instruments were included in Châtelier, "Le Système Taylor.". In Germany, they were included in Gilbreth, *Das ABC Der Wissenschaftlichen Betriebsführung*. Martin Wagner would provide the most extensive explanation of Gilbreth's earlier construction work in the two magazines he edited during the twenties, *Soziale Bauwirtschaft* and *Wohnungswirtschaft*. Both magazines took their names from the German translation of systematic management, *wirtschaftliche Betriebsführung*. There is no book length study of Gilbreth's work. Brian Price's 1987 doctorate, which builds upon David Nelson's research is summarized in Brian Price, "Frank and Lillian Gilbreth and the Motion Study Controversy, 1907-1930," in *A Mental Revolution: Scientific Management since Taylor*, ed. Daniel Nelson (Columbus: Ohio State University, 1992). The more recent biography on Lillian Gilbreth only briefly outlines their collaboration between 1912 and 1925, Jane Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond "Cheaper by the Dozen"* (Boston: Northeastern University Press, 2006).

⁴² In 1904, he offered a more *conscious* approach to typological evolution, through the work of Norman Shaw at Bedford Park, an "experiment" where the "small house type" was "evolved". Hermann Muthesius, *The English House, Volume I: Development*, trans. Janet Seligman (London: Frances Lincoln Ltd., 2007 (1904)). Muthesius used Norman Shaw's work at Bedford Park as an example of how a 'modern architect' could use settlement-building, with its repetition and difference over time, to a "evolve a type".

⁴³ "Das Formproblem Im Ingenieurbau," *Werkbund Jahrbuch* (1913). The modern engineer, like the practitioners of English domestic architecture were now presented as two potential models for the modernist architect, one that would consciously and individually participate in the unconscious collective process of typification, or type-making.

⁴⁴ James Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, MA: The Harvard University Press, 1986). Antoine Picon has used this historiographical concept in Antoine Picon, *Digital Culture in Architecture: An Introduction for the Design Professions* (Basel: Birkhauser, 2010).

been engaging with more directly, on a case by case basis, into firm legislative artifacts, in the form of copyrights and building regulations, and therefore defining the national and international contexts in which they practiced. Muthesius felt that by imposing these legislative artifacts, the “*sachliche* progress” of twentieth century architecture would be *blocked*, just as Academicism had “blocked” it in the 19th century.⁴⁵ The third of the intermediaries whose work supported this translation was Raymond Unwin (1863-1940).⁴⁶ Unwin’s “organizational schemes” and general methods of site design and visual planning, included in *Town Planning in Practice* (1909)⁴⁷ provided a foundation for modernist *laboratories* and *experimental settlements* comparable to the one that systematic management offered scientific management. This manual broke down and abstracted standard urban morphologies, streets and *places*, into interchangeable parts, at the unit scale. With this already rationalized system, architects could apply the instruments of scientific management to manage the perception and production of the settlement at the building component scale, in synchronic time, as well as to manage experimentation and standardization of unit types in diachronic time.⁴⁸

⁴⁵ Hermann Muthesius, "Neues Ornament Unde Neue Kunst," *Dekorative Kunst* 4, no. 9 (June 1901). Translated by and discussed in Stanford Anderson, "Sachlichkeit and Modernity, or Realist Architecture," in *Otto Wagner: Reflections on the Raiment of Modernity* ed. Harry Mallgrave (1996).

⁴⁶ Walter Creese, *The Search for Environment: The Garden City, before and After* (Baltimore: The John Hopkins University Press, 1992 (1966)). *The Legacy of Raymond Unwin: A Human Pattern for Planning* (Cambridge: The MIT Press, 19__). Robert Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier* (Cambridge: MIT Press, 1982). Despite of this scholarship, Unwin’s continued influence of modernist architecture is rejected by Frampton, *Modern Architecture: A Critical History*. Unwin’s unique background combined technical training as a mining engineer, skill in visual planning garnered from an education with John Ruskin at Oxford, experience in social activism and later in political lobbying as well as familiarity with the “principles of organization” of Britain’s “great industries” and the unique agency that German municipalities, as well as German architects, had had in urban design during the last decades of the 19th century.

⁴⁷ Raymond Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1909).

⁴⁸ Unwin also offered a model of experimental derivation comparable to that of NADI in his manual, following Ebenezer Howard’s theories of “municipal experimentation”. Howard explained that the garden city was to function as an experiment on two levels, internally, with policies developed through trial and error, and

The primary goal of *experimenters* like Frederick Taylor and Frank Gilbreth, or Le Corbusier and Ernst May, was disciplinary innovation, in the form of new methods, parameters and instruments for assisting the mental work of one's peers. As such, economic efficiency, social equilibrium and even the influence of one's legislative context came second to this primary goal, although claims of success in these three areas, whether actually achieved or not, often accompanied their dissemination. In my own assessment of the work of those architects that actually engaged in scientific management's laboratory method, I will certainly not claim, nor accept their claims, that the conclusions of their work was more rational, objective or scientific as a result of the use of the laboratory method, but rather, I will use their experience of experimentation, to more critically assess that work.

Success in clearly explaining and disseminating these innovations to other members of one's discipline, or outside of it, was as crucial and often as elusive as the experimental derivation of the standards themselves. Within the Taylor Circle, Frederick Taylor was probably the least proficient in this important endeavor, with Frank Gilbreth explaining Taylor's own work as well as his own, much more clearly, in both English and German.⁴⁹ In France, Henri Le Châtelier's March 1914 explanation of Taylor's laboratory method, as well as a complete survey of Frank Gilbreth's advanced visualization tools, would provide Le Corbusier access to these methods, in his native language, well before many American

externally with those innovations that proved most useful being proposed as national legislation. Ebenezer Howard, *Garden Cities of to-Morrow* (London: Swan Sonnenschein & Co., 1902). Raymond Unwin worked with British MP John Burns to pass the Hampstead Act of 1906, giving the site autonomy from current building regulations. Unwin discussed this in Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*. For more on Hampstead see Creese, *The Search for Environment: The Garden City, before and After*.

⁴⁹ Horace Bookwalter Drury, "Scientific Management: A History and Criticism" (Columbia University, 1915). Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915."

industrial engineers.⁵⁰ Le Corbusier's own laboratory method at Pessac was already foreshadowed in his 1922 article, "Houses in Series", a text whose evolution in subsequent editions of *Toward an Architecture*, from 1923 until the definitive third edition in 1928, would reflect his initial enthusiasm and eventual disappointment with this taxing mode of conjecture.⁵¹ In the first French edition of *Oeuvre Complete* (1929), as well as in the 1930 German translation, Le Corbusier organized a significant part of the publication as a mapping of the evolution from the notion of a "house in a series" to a "standardized villa", through a series of experimental sites at Bordeaux. In later editions, a much more open discussion of this work in terms of trial, as well as *error*, was replaced by an account omitting many of these *errors*, a key part of the feedback produced by the laboratory method.⁵² Nevertheless, many of the most important methods of modernist design practice, including the *plan libre*, were initially presented as the fruits of "laboratory work"⁵³, a claim that I will demonstrate was not only true but reflected Le Corbusier's accurate understanding of what constituted scientifically managed architectural practice.

Between 1921 and 1925, Martin Wagner would ensure German-speaking architects access to clear explanations of the general principles and instruments of scientific management through the dozens of articles included in two journals that he edited during

⁵⁰ Châtelier, "Le Système Taylor."

⁵¹ Le Corbusier, "Maisons En Série," *L'Esprit Nouveau* 13(1922). A good overview of the history of *Toward an Architecture* is included in the introduction to the new translation, Jean-Louis Cohen, "Introduction," in *Toward an Architecture* (Los Angeles: Getty Research Institute, 2007).

⁵² By 1936, the Maison Du Tonkin and Lège were removed and with them, two of the three phases of experimentation and standardization in Bordeaux. Mary McLeod has pointed out that all references to Taylor and Taylorism were also removed from the English translation of *Toward an Architecture*. I have examined the German translations, and they remained from 1926 onward, with *Taylorisme* being translated as the "Taylor-System". Since Giedion cited this edition in Sigfried Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton*. (Berlin: Klinkhardt and Biermann Verlag, 1928). it means that he probably knew but chose not to reveal the source for Le Corbusier's novel mode of design, which he called *Standardisierung*, his translation of standardization, more commonly translated as *Rationalisierung* in Germany by 1928.

⁵³ Le Corbusier, *The Marseilles Block* [L'unité d'habitation de Marseille], trans. Geoffrey Sainsbury (London: The Harvill Press, 1953 (1950)).

that period, *Soziale Bauwirtschaft* and *Wohnungswirtschaft*. By 1926, Ernst May began publishing his own journal in Frankfurt, giving architects access to the *gradual evolution of types* through his experimental settlements.⁵⁴ Through the application of the laboratory method, the RFG was able to collect and disseminate detailed assessments of the experimental program in a series of reports published in April 1929, carried by German émigrés to other countries during the thirties.⁵⁵ In May's case, I will also show that in addition to providing instruments and methods for disciplinary use, he also provided a model for a new kind of drawing set as part of his work in Moscow in 1932.⁵⁶ That information technology would be used to plan and project the largest program of industrialized housing delivery ever attempted, during the postwar period in the Soviet Union. As with the management of the factory, at the turn of the century, the territorial-scaled space of production of industrialized housing delivery would be managed by engineers, with architects providing a constrained set of services, and thus lacking access to these instruments or the opportunity to engage in further experimentation.

STATE OF THE QUESTION

At the core of my primary question, namely what constituted a scientifically managed architecture for European modernist architects during the period from 1918 to 1932, is another question, what is scientific management? My own use of the term is

⁵⁴ Pessac was first published outside of Germany in Ernst May's *Das Neue Frankfurt* in October 1926. This was also the first mention of Taylor and Taylorization in that journal. Mary McLeod has pointed to the mutual respect between these two architects in McLeod, "Architecture or Revolution': Taylorism, Technocracy, and Social Change."

⁵⁵ Copies of these reports were brought to Harvard by Gropius in 1936, and were also brought by May to the Soviet Union in 1930. Andreas Schwarting has also shown that Ernst Neufert drew on these standards for his own manuals. For a discussion of Neufert, an employee of the RFG, see Gernot Weckherlin, "Ernst Neufert's Architects' Data: Anxiety, Creativity and Authorial Abdication," in *Architecture and Authorship*, ed. Katja Grillner and Rolf Hughes Tim Anstey (London: Black Dog, 2007).

⁵⁶ These drawings are held at the Canadian Centre for Architecture in Montreal and were discussed in Evans, "Architectural Projection." And included in the catalogue of that exhibition.

founded in a significant reassessment of scientific management that began within the discipline of industrial management itself, following the publication of David Nelson's article, "Scientific Management, Systematic Management, and Labor, 1880-1915" in 1974.⁵⁷ Nelson studied the forty-six privately owned industrial firms and two government facilities in America, where members of the Taylor Circle developed scientific management between 1901 and 1917, comparing the principles of scientific management to their practice by its authors. He found that while scientific management did not provide even the "partial solution to labor problem" that Taylor himself had promised it would, it did constitute a "comprehensive answer to the problems of factory coordination", one that had continued to inform manufacturing practice up to the seventies. Nelson found that Taylor himself had a difficult time living up to his own ideals, but that his own successes were generally attributable to his principles. His research also gave agency to the heterogeneous mix of Taylor's associates, many of whom were more successful than Taylor himself in installing scientific management through their own consulting work and expanding influence from the privately owned machine shop, to government and cooperatively owned facilities, as well as to other countries and disciplines. Nelson's work has also supported new research by other scholars and has led to the conclusion that the use of the term Taylorism has "been rather sloppy"⁵⁸, and that the "uniformity implied by the term 'Taylorism' emerged later, in the 1940s" and was probably "imposed by government regulators and industrial

⁵⁷ Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915."

⁵⁸ Michael J. Piore, a Professor of Economics at MIT came to these conclusions in 1995, as part of his review of "Industrial Engineering and the Industrial Enterprise, 1890-1940." For the more standard use of the term Taylorism commonly used before Nelson's work see Braverman, *Labor and Monopoly Capital: The Degredation of Work in the Twentieth Century*. Braverman's notion of Taylorism that is commonly used in critical theory, such as David Harvey, *The Condition of Postmodernity* (Cambridge: Blackwell Publishers, 1990).

unions.”⁵⁹ Nelson’s original research provides a useful tool in assessing the primary manuals and articles of scientific management, as well as for comparing the development of certain innovative industrial engineering instruments with architectural ones, through the use of the laboratory method.⁶⁰

With this more historically and theoretically nuanced understanding of what constituted scientific management, it is possible to address the more specific question of what would constitute scientifically managed modernist architecture, between 1918 and 1932. Mauro Guillen’s *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture* (2006) is the broadest attempt to address this question. A byproduct of Guillen’s earlier study, *Models of Management* (1994), the later book followed the same research methodology, mapping out the history of the dissemination of this particular “model of management” from the discipline of industrial engineering in America to the discipline of architecture in Britain, France, Germany, Italy, Russia, Spain and Argentina.⁶¹ This valuable overview suffers from the author’s lack of training in architectural history, as well as the source material itself; whereas the 1994 research used

⁵⁹ Piore again in Nelson, "Industrial Engineering and the Industrial Enterprise, 1890-1940." The “sloppy” use of the term Taylorism has been challenged for some time. In industrial sociology, Craig Littler, a British sociologist, critiqued Braverman’s use of the term in Craig R. Littler, "Understanding Taylorism," *The British Journal of Sociology* 29, no. 2 (June 1978). Littler found that much of what was defined as Taylorism was specific to America, and even though Taylor was influential on Great Britain as well, the postwar ramifications of the this translation differed significantly. Braverman’s argument that the “interest of the capitalist and the manager are identical” was also disproved by Judith Merkle, *Management and Ideology: The Legacy of the International Scientific Management* (University of California Press, 1980). Here individuals with very different ideological backgrounds were nevertheless drawn to aspects of scientific management. In Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power*, the author shows how the attitudes toward and the application of scientific management changed over the history of the Soviet Union.

⁶⁰ One of the most detailed accounts of a particular installation of scientific management is Daniel Nelson, "Taylorism and the Workers at Bethlehem Steel, 1898-1901," *The Pennsylvania Magazine of History and Biography* 101, no. 4 (1977).

⁶¹ Guillen, *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture. Models of Management: Work, Authority and Organization in a Comparative Perspective*. Guillen is a Professor of International Management and Sociology at the Wharton School of the University of Pennsylvania.

a much larger data set of professional journals, the 2006 study relies mostly on secondary sources. Furthermore, it lacks a distinction between the uses of the term in general discourse and the application of it in practice.⁶²

Within the field of architectural history, the first, and still most comprehensive, history of the work of Frederick Taylor and Frank Bunker Gilbreth is included in Sigfried Giedion's *Mechanization Takes Command* (1948).⁶³ Here Gilbreth is given significantly more attention than Taylor, and is given the prestigious title of "master of space-time studies". Nevertheless, Giedion did not seem aware of, or chose not to acknowledge, the very direct relationship between Gilbreth and modernist architecture, choosing instead to maintain that his principles came to architects via the synthesis of "new methods and materials of construction" of civil and mechanical engineering, as well as through the "artistic discoveries that had been made since 1910" in Cubism and Futurism that occurred around 1926.⁶⁴ A more thorough history of Frank Gilbreth's innovative application of

⁶² This does not prevent the author from making general conclusions about when scientific management was first discussed or what the relationship constituted, advocating the replacement of the "machine aesthetic" with a new "organizational aesthetic" concept, one that still assumes that architects only superficially admired the discourse of scientific management, as some earlier scholars have argued they admired the spaces and products of industry, such as Reyner Banham, *A Concrete Atlantis: Us Industrial Buildings and European Modern Architecture: 1900-1925* (1980). Here Banham shifts from his earlier more operative arguments about modernist architects not engaging technology, but that contemporary architects in 1960 should, to agreeing with Robert Venturi that modernist architecture included a "a vocabulary of forms based on a variety of industrial models whose conventions and proportions were no less explicit than the Classical orders of the Renaissance". What neither author even considered was how the methods of industrial organization might have displaced or transformed those of Academic composition.

⁶³ Sigfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* (New York: Norton, 1974 (1948)).

⁶⁴ Giedion also showed little sympathy for the laboratory method maintaining the earlier unconscious or "anonymous" authorship of industrial production as distinct from the intentional and conscious authorship of art and architecture. Nikolaus Pevsner's 1936 assessment that the older ideas of "artist as the high priest in a secularized society" had been eliminated by modernist architecture has proved to be premature. Giedion's late discovery of scientific management, exactly thirty years after Le Corbusier and Peter Behrens, may have been informed by his former collaborator and fellow émigré to America, Laszlo Moholy-Nagy, who imagined Gilbreth's influence on Futurism in Laszlo Moholy-Nagy, *Vision in Motion* (Chicago: Farnham, 1947). In many ways, Moholy-Nagy's more radical notions of a "new vision", informed by the experience of the city as seen through new optics, were much closer to the principles of scientific management.

scientific management principles to construction, before he met Frederick Taylor, in 1907, and before he and Lillian shifted their focus from the construction plant to the industrial plant, in 1912, is included in Tom Peters, *Building the 19th Century* (1995).⁶⁵ Historically, my own research picks up where Peters' work ends, around 1918.

The most thorough investigation of the impact of modern management discourse, including systematic and scientific management, on professional architectural discourse, during the period I am investigating is Hyungmin Pai's *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America* (2000). Much more rigorous than Guillen in his use of professional journals as the primary source of research material, Pai provides a detailed map of the evolution from a professional discourse centered on Beaux Arts principles, which largely colored the way in which the discourse of Taylor, Gilbreth and other industrial engineers was absorbed, and also demonstrates the impact of the German discourse of scientific management in America. Unfortunately, Pai still relies on an outmoded definition of Taylorism in his discussions of Taylor and Gilbreth, misreading the graphic instruments as "diagrams" as opposed to graphic projection instruments.⁶⁶

While there has been no study to date that has focused on the application of Taylor's laboratory method, or of Gilbreth's visualization theory and instruments, to architectural practice⁶⁷, Le Corbusier's 'laboratory' at Pessac and Walter Gropius' 'experimental

⁶⁵ Peters' work also provides a useful contextualization of what was actually novel about Taylor's and Gilbreth's respective contributions to what he calls 'systems thinking' in building. He also includes a brief history of the application of some of the instruments of scientific management to infrastructural construction by American and Swiss engineers during the teens, immediately prior to the first articles on scientific management written by Peter Behrens and Le Corbusier.

⁶⁶ Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America*.

⁶⁷ In terms of methodology and subject matter, the closest studies to my approach are those conducted by Robin Evans, examining the application of novel orthographic or perspectival projection tools to architectural practice. For this approach see Robin Evans, *The Projective Cast: Architecture and Its Three Geometries*

settlement' at Törten have both been examined in detail, with partial consideration given to the influence of Taylorism or scientific management. Bryan Taylor's exhibition catalogue, "Le Corbusier at Pessac" (1972), is the most thorough study of this project to date.⁶⁸ This work, frequently cited by scholars, is limited in its assessment of the application of scientific management in this project by the author's own lack of familiarity with the primary texts of scientific management, as well as the general lack of secondary sources on its history at that time.⁶⁹ Andreas Schwarting's recent study, *Die Siedlung Dessau-Törten* (2010), offers a much more in depth assessment of this project than Bryan Taylor's study of Pessac. Through his knowledge of architectural projection, construction and legislation, Schwarting is able to more accurately assess how the theories and practices of scientific management were applied to architecture, finding ample evidence of a thorough translation, which nevertheless did not ensure economic efficiency.⁷⁰ Martin Wagner's

(Cambridge: MIT Press, 1995). In terms of engineering construction, a similar approach is applied in Peters, *Building the 19th Century*: . Both have served as models for my methodology.

⁶⁸ Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. The only other book-length study of this important project, Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale.*, provides useful primary material, including Le Corbusier's speech on the project, given in May 1926 as well as an interview with Henri Fruges, Le Corbusier's client and collaborator on the projects, given in 1967, but is otherwise more focused on the state of the project in the sixties. Bryan Taylor's conclusions serve as the primary evidence that Le Corbusier was in fact more interested in the "political and social implications" of the "application of efficiency engineering to labor relations" at a national scale than "Taylorism's strictly technical features," in McLeod, "'Architecture or Revolution': Taylorism, Technocracy, and Social Change."

⁶⁹ For example, Bryan Taylor correctly points out that Le Corbusier's choice of purchasing a cement gun proved costly but not in his assessment that the purchase itself constituted a breach with the principles of scientific management any more than the decision not to use it would have been. Le Corbusier's lobbying to build a single house, the Maison du Tonkin, in order to experimentally revise the basic unit type, the standard module to be used and to help estimate the cost, before planning and constructing Lège, the smaller settlement, that in turn informed Pessac, are all methods directly attributable to scientific management, just as his continued use of proportions can be attributed to Academic composition. These same problems at Pessac do not reflect the lack of scientific management, but are in fact the direct result of the costly and cumbersome laboratory method. The laboratory method does not make Le Corbusier's standard design methods, experimentally derived and standardized in Bordeaux, objective, scientific or rational but they do constitute *laboratory work*, as he himself would later claim.

⁷⁰ Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*. Schwarting's research supersedes many of the earlier accounts of Törten, such as Gilbert Herbert, *The Dream of the Factory-Made House* (Cambridge: The MIT Press, 1984). and Leah Dickerman Barry Bergdoll, ed. *Bauhaus, 1919-1923*:

interest in scientific management has been acknowledged in a number of publications, his particular characterization of Frank Gilbreth has never been discussed in detail.⁷¹ Despite the significant body of literature on Ernst May's work, there has been even less discussion of his application of the laboratory method and the instruments of experimentation and standardization.⁷² One explanation for this omission may be May's own persistent use of terms such as "evolution" rather than "standardization".⁷³

In answering my primary question, what constituted a scientifically managed architecture, I have also addressed an important related question, namely what factors influenced the interest in scientific management, starting in 1918, and informed its subsequent applications between that year and 1932? Far from a break with current disciplinary preoccupations, the embrace and comprehension of scientific management reflected the existence of an existing theoretical framework most directly attributable to Hermann Muthesius. Francesco Passanti has already demonstrated the importance and persistence of what he has called the 'vernacular as conceptual model' in Le Corbusier's interwar work, a theoretical lens Passanti attributes to Muthesius.⁷⁴ Stanford Anderson's

Workshops for Modernity (New York: MoMA, 2010). His chapter length history of the RFG and the experimental settlements program also significantly expands and refines the understanding of this program from earlier accounts, such as Lane, *Architecture and Politics in Germany, 1918-1945*

⁷¹ The most thorough discussion of Wagner's interest in scientific management is included in *Martin Wagner 1885-1967: Wohnungsbau Und Weltstadtplanung*. (Berlin: Akademie der Künste, 1986). It is also discussed in Manfredo Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's* (Cambridge: The MIT Press, September 1987).

⁷² Claudia Quirling, *Ernst May: 1886-1970*. Of the earlier scholarship on May, Dietrich Andernacht and Gerd Kuhn, "'Frankfurter Fordismus,'" in *Ernst May Und Das Neue Frankfurt 1925 - 1930* ed. Rosemarie Höpfner and Volker Fischer (Frankfurt: Deutsches Architektur Museum, 1986). is still the most impressive assessment of the particular political and economic context within which May evolved his types.

⁷³ May never mentioned Taylor or Gilbreth directly, only indirectly, through articles written by Le Corbusier and Walter Gropius, published in *Das Neue Frankfurt*. His own discourse retained a much more *Muthesian* vocabulary throughout the twenties, even as he developed some of the first "motion plans" at the scale of the entire settlement.

⁷⁴ Francesco Passanti, "The Vernacular, Modernism, and Le Corbusier," *Journal of the Society of Architectural Historians* 56, no. 4 (December 1997). Passanti shows that Hermann Muthesius was crucial in helping Le Corbusier separate and preserve the theoretical *concept* from the more formal *model* of his youth and

argument that Peter Behrens never fully grasped the creative potentials of Hermann Muthesius' theories, but that his former employee, Le Corbusier did⁷⁵, has also proven useful for understanding why the more seasoned factory-builder nevertheless failed to translate his earlier experiences into settlement-building. I have also built upon Robert Fishman's 1982 discovery that it was "Unwin, rather than Howard, who interested" Le Corbusier and influenced his Domino System, in 1914-15, finding that Unwin's methods continued to inform the architects through 1926, providing a form of systematic management of his mental work onto which the laboratory method was applied.⁷⁶ Additionally, I will show that a number of parallels in terms of a mastery of Unwin's methods, the persistence of Hermann Muthesius' theories and the willingness to apply the laboratory method exist between Le Corbusier and Ernst May.

Building upon recent scholarship on the history of scientific management and on modernist architecture, immediately prior to 1918, this dissertation provides an account of the translation of the theories and practices of key American industrial engineers by influential European modernist architects. Although Taylor's laboratory method and some of the more advanced instruments of Gilbreth's visualization theory never became

adolescence. The Swiss-French architect's eyes had already been trained to see evolution and adaptation in vernacular architecture, they has also identified the same characteristics in industrial products, Hellenic temples before they discovered Taylor's account of the *engineers aesthetic*, one that also viewed the world in the diachronic terms on similar terms but that also offered a set of projective instruments for planning processes in space-time.

⁷⁵ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*.

⁷⁶ Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier*. The link between Le Corbusier and Unwin has also been explored by Richard Etlin, *Le Corbusier and Frank Lloyd Wright: The Romantic Legacy* (1994). and by John MacArthur, *The Picturesque: Architecture, Disgust and Other Irregularities* (2007). This research shows the clear persistence and evolution visual planning, attributable to Unwin, Camillo Sitte as well Auguste Choisy, in the work of Le Corbusier. Unwin's relationship to Ernst May is well documented, but his work has never been analyzed in detail with this in mind. A more detailed discussion of the use of Unwin's manual by Hermann Muthesius at Hellerau is included in Laurent Stalder, *Hermann Muthesius, 1861-1927: Das Landhaus Als Kulturgeschichtlicher Entwurf*. (Zurich: GTA Verlag, 2008).

widespread in industrial engineering or in architecture, important disciplinary practices, still in use today, such as critical path planning and free planning, were both experimentally derived and standardized.⁷⁷ This research also suggests a much earlier engagement of architecture and “programming”, a mode of making that Norbert Wiener, the “father of cybernetics” had attributed to “Taylor and the Gilbreths”, one that “offered considerable difficulty in detail, but not great difficulty in principle” to be “transferred” from the use of human beings “in the factory ... to the machine.”⁷⁸ The adoption of Gilbreth’s visualization theories and methods by modernist architects to project processes in space-time also constitutes a significant shift for the discipline during the early twentieth century, on par with the development of orthographic and perspectival projection to precisely conceive objects and fixed spatial relationships, during the 15th century. Furthermore, this research offers a novel example of architects actively engaged in the shaping of their legislative contexts, through the development of standards and regulations. Finally, this dissertation offers a model of progressive practice distinct from that of the avant-garde, and instead one of experimentalism, which is able to engage and evolve societal and disciplinary conventions through the extension of the process of conjecture from the mind and drawings of a single practitioner, through the process of production and into use itself.

CHAPTER OUTLINE

In Chapter 1, I will define the ‘laboratory method’, using a number of texts written by members of the Taylor Circle, including Frederick Taylor, Henry Gantt, William Cooke,

⁷⁷ Critical Path Planning was a further refinement of the Gantt chart and Gilbreth’s “process chart”, developed at Du Pont, in 1956. For more on critical path planning see Stuart G. Walesh, *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields* (Hoboken: Wiley, 2000).

⁷⁸ Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society*, Da Capo Series in Science (Boston: Houghton Mifflin Company, 1954 (1950)).

Frank Gilbreth and Lillian Gilbreth. This material will be further supplemented with texts by important advocates outside of the Circle, including Frank Copley, who wrote the 1922 biography of Taylor, Henri Le Châtelier, one of his earliest advocates in Europe, Daniel Hauer, who completed the translation of scientific management into construction that Frank Gilbreth started, and Aleksei Gastev, the director of the Soviet Center for Labor.⁷⁹ I will also include a brief survey of Hermann Muthesius' theorization of typological evolution and adaptation, starting in 1901 and ending in 1920, when the German theorist and Werkbund founder wrote an important, and generally unknown, text synthesizing his earlier theories on type, settlement design practice and scientific management, through the conscious and collective act of *Typenbau*, or "type building", a conscious participation in the evolution of types.⁸⁰ I will then compare this text with Peter Behrens' 1918 discussion of type, the "settlement question" and scientific management⁸¹, and with two texts of his former employee Le Corbusier, the first in 1918, which discussed Taylor and Taylorism,

⁷⁹ I have gathered, scanned and applied Optical Recognition Software to a number of primary publications of scientific management as well as professional journals from the period to identify key discussions of the laboratory method, before analyzing and comparing these texts in greater detail. Google's open source digital library has made this process possible. I will indicate which sources were directly accessible to European modernist architects and which sources influenced the discourse surrounding scientific management more broadly. These primary texts will also show that some modernist architects comprehended the implications of the 'laboratory method' before they were explained in the engineering disciplines. I will also discuss the experiences that informed the laboratory method, relying on Nelson's research as well as Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*.

⁸⁰ I am referring here to two chapters included in Hermann Muthesius, *Kleinhaus Und Kleinsiedlung*, 2nd ed. (Munich: F. Bruckmann, 1920). They are "Der Typenbau", a shorter version of which was included in the 1918 edition, and "Wirtschaftliche Baubetriebsformen", a new chapter on scientific management, Frederick Taylor and Frank Gilbreth. The only discussion I have found of this manual is included in Stalder, *Hermann Muthesius, 1861-1927: Das Landhaus Als Kulturgeschichtlicher Entwurf*. While there is no discussion of scientific management, Stalder does provide evidence of the manual's importance and impact, republishing a number of reviews from the period.

⁸¹ Heinrich de Fries Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* (Berlin: Verlag der Bauwelt, 1918). The manual is briefly discussed in Fritz Neumeyer, "The Workers' Housing of Peter Behrens," in *Industriekultur: Peter Behrens and the Aeg, 1907-1914*, ed. Tilmann Beddensieg in collaboration with Henning Rogge. Stanford Anderson's explanation of why Peter Behrens never fully comprehended Hermann Muthesius' theories of type will be used to help interpret his lack of comprehension of the laboratory method, despite his exposure to the Taylor System at the AEG, as early as 1908, and even his description of the method, here. Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*.

and the second in 1920⁸², which discussed experimentation and standardization. While varied in background and motivation, all of these author's will demonstrate a comprehension of scientific management's distinguishing characteristic, the laboratory method.

In Chapter 2, I will examine the novel graphic projection instruments and associated project management developed by Frederick Taylor, Henry Gantt and particularly Frank Gilbreth. I will first compare Taylor's initial development of the "instruction card", an instrument used in experimentation, and Gantt's initial development of the "graphic daily balance in manufacture", an instrument used in conjunction with the instruction card in standardization, to Frank and Lillian Gilbreth's modifications to these instruments, between 1901 and 1912.⁸³ Then I will examine Frank Gilbreth's instruments and methods developed for construction, between 1895 and 1909.⁸⁴ Finally, I will examine Frank and Lillian Gilbreth's instruments and methods, which while developed for manufacture, had

⁸² The first text is a section of Amédée Ozenfant and Charles-Edouard Jeanneret, *Après Le Cubisme* [After Cubism], Commentaries Sur L'art Et La Vie Modern (Paris November 15, 1918). This section is titled "L'Esprit Moderne", a spirit that Le Corbusier would equate with Taylorism. The second text is Le Corbusier, "Des Yeux Qui Ne Violent Pas... Iii: Les Autos," *L'Esprit Nouveau* 10(1920). Here, more than in 1918, Le Corbusier shows full comprehension of the laboratory method and correctly explains the two linked activities of "experimentation" and "standardization". While both texts have been discussed by a number of scholars, this text has not been compared to the 1920 Muthesius discussion, which also included Hellenic Temples and scientific management theory. As Le Corbusier would later explain, this was his first use of the term standardization, an important concept that Le Châtelier himself did not discuss, focusing more on experimentation. For Le Corbusier's discussion of the importance of this text, I will also briefly examine *The Marseilles Block*.

⁸³ In addition to the primary articles and manuals of scientific management, I also utilize the extensive Frank and Lillian Gilbreth Library of Management Research and Professional papers, 1845-1959, at Purdue University.

⁸⁴ In a unique decision, one that would later be praised by Martin Wagner, Frank Gilbreth published his construction company's internal standard methods and parameters as series of publications between 1908 and 1909. They were Frank Bunker Gilbreth, *Concrete System* (New York: The Engineer News, 1908), *Field System* (New York: The Myron C. Clark Publishing Co., 1908), and *Bricklaying System* (New York: Myron C. Clark Publishing, 1909). *Bricklaying System* was part standard method part manual. The manual portion became *Motion Study: A Method for Increasing the Efficiency of the Workman* (New York: Norstrand, 1911), already more of a conventional manual. Archival research has shown that these earlier publications were what they claimed they were, tentative standards taken directly from practice. Copies of the originals are included in the Gilbreth Library at Purdue University.

been informed by Frank's work in construction, between 1912 and 1916, during consulting work in America and Germany.⁸⁵ I will also distinguish between Frederick Taylor's more numerical aesthetic sensibility and Frank Gilbreth's "visualization theory", one that sought to describe motions in space and time, rather than in abstracted numerical patterns.⁸⁶ In all three sections, I will illustrate the primary means of dissemination to architects.⁸⁷

Between 1908, when Frank Gilbreth's manuals of scientifically managed construction first appeared, and 1918, when European modern architects first began to address scientific management in their writings and to apply it to their practice, a number of important partial applications of this approach were attempted by American architects and engineers. In Chapter 3, I will examine three of these applications, the Atterbury System, the Harms and Small System and the Unit System. All three of these systems would later inform the interwar work in Europe, providing a model for scientifically managed fabrication and construction of settlements. The translation of these approaches from the

⁸⁵ Gilbreth first published these new methods in a series of articles, "Micro-Motion Study: A New Development in the Art of Time Study," *Industrial Engineering and the Engineering Digest* XIII, no. 1 (January, 1913), his approach to experimentation, and "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation," *Industrial Engineering and the Engineering Digest* XIII, no. 2 (February, 1913), his approach to standardization. I will also examine a series of lectures given on these studies in America and Germany during this period. His final article on this subject is F B Gilbreth, "Process Charts: First Steps in Finding the One Best Way to Do Work (Lecture, December 1921)," *The American Society of Mechanical Engineers* (March 1, 1922).

⁸⁶ Robert Kanigel's account of Taylor's youth provides an excellent foundation for understanding his particular aesthetic sensibility and also explains why he himself never felt the need to develop visualization tools. Frank Gilbreth applied the term "visualization theory" to the instructions for his team for what would be his last complete installation of his principles at Carl Zeiss in Jena, Germany in May 1915; it provides a unique synthesis of his approach to processes in space-time.

⁸⁷ German-speaking architects had access to comprehensive survey of the graphic instruments and project management methods of scientific management methods by 1917 through Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*. More than a translation of Gilbreth, *The Primer of Scientific Management*, the German manual included work that was never published in America. French-speaking architects had access as early as March 1914 through Châtelier, "Le Système Taylor." Here, Gilbreth's methods were also included as part of 'le système Taylor'. The most comprehensive survey of Gilbreth's construction techniques was provided by Martin Wagner, particularly in two articles, Martin Wagner, "Wirtschaftliche Betriebsführung Im Baugewerbe," [Systematic Management in the Building Trades.] *Soziale Bauwirtschaft* 1, no. 7 (1 April 1921). and "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert," [How an American Contractor Promoted Systematic Management.] *Soziale Bauwirtschaft* 5, no. 3 (1 February 1925).

management of construction to the management of design was assisted by a common methodological foundation, Raymond Unwin's 1909 manual, *Town Planning in Practice*. I will discuss this manual in detail, before moving to an analysis of the three American systems.

In Chapter 4, I will shift focus from the earlier application of scientific management to the fabrication and construction of settlements to a more direct use of these principles to architectural production, the production of drawing sets. Here, I will focus on two case studies of architectural production systems, informed by scientific management, Peter Behrens' *Gruppenbauweise*, or "grouped building method", first published in March 1918, and first applied later in the same year, and Le Corbusier's *maisons en série*, or "houses in series", first published in 1922, and first applied in late 1923. While both architects shared a common early exposure to scientific management, as well as a knowledge of Hermann Muthesius' theories, Raymond Unwin's methods of settlement design, and the emerging industrial vernacular of American 'Concrete Towns', it would be Le Corbusier who would first successfully apply the laboratory method to what would later be called the "rationalization of the mental work" of the architect. This work of the early twenties would in turn directly inform the more complete application of scientific management, including the laboratory method and the Gilbreths' visualization theory, to the experimental settlements program in Germany, between 1926 and 1930.

Chapter 5 will focus on two "experimental settlements", managed by Walter Gropius and Ernst May as part of a program modeled on NADI, with the explicit goal of experimentally deriving and standardizing standard methods, parameters and instruments for use in Germany, between 1926 and 1930. With the assistance of this program, Gropius

and May came closest to scientifically managing every part of architectural production, from individual conjecture to post-occupancy surveys. The unique Weimar context also allowed these architects to experiment with the role of the architect in defining the broader relationship of *scientific management and the State*, a topic only theorized by a few members of the Taylor Circle, including Frank Gilbreth (1917) and Henry Gantt (1919). In addition to providing a general background of the association that supported this program, the RFG, I will offer insight into the mindset of the program's director, Wilhelm Lübbert, a German architect with an extensive knowledge of the Weimar bureaucracy.⁸⁸ As in Chapter 3, Unwin's manual proves essential, providing practical examples of the application of Ebenezer Howard's theory of the settlement as a space of *municipal experiment* for developing national regulation and housing policy. I will also compare the experimental settlements program to other work supported by the RFG, particularly that of Alexander Klein, in order to distinguish the application of the laboratory method versus the more rationalistic approach to the derivation of standards usually associated with modernist architecture and Taylorism.⁸⁹

In conclusion, I will consider what factors contributed to the interest in and application of scientific management by European modernist architects to settlement-building, during the twenties, and hypothesize what factors may have contributed to the general lack of architect-managed *laboratories* or *experimental settlements* during the

⁸⁸ Wilhelm Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]* (Berlin: Arbeitsgemeinschaft für Rationalisierung im Bauwesen/Beuth Verlag 1926). This publication set the criteria through which the experimental settlements would be judged.

⁸⁹ A number of scholars have used Klein's work as exemplary of a Taylorist approach to modernist architecture, for example Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America*. Or Walter Prigge, "Regulierung," in *Ernst May Und Das Neue Frankfurt 1925 - 1930* ed. Rosemarie Höpfner and Volker Fischer (Frankfurt: Deutsches Architektur Museum, 1986). I will show that Ernst May and Walter Gropius' approach was, in many ways, the diametrical opposite of Klein's.

postwar period. To address this issue, I will first briefly examine of a set of national standards for industrialized housing delivery that Ernst May developed for the Soviet government, in 1932, a project that marked the end of this brief period of experimentation and foreshadowed the ontological and organizational structure of the postwar period and a general trend towards the ‘over-bureaucratization’ of housing delivery, on both sides of the Iron Curtain. I will then discuss the Jugomont System of industrialized housing delivery, developed by a team of architects working in, and briefly running a ‘self-managed’ construction company, based in Zagreb, then part of Socialist Yugoslavia. In spite of Yugoslavia’s technologically backward and highly decentralized, and balkanized, building industry, these architects were able to develop a large-scale delivery system, comparable in relative scale to the engineer-designed and managed systems used in France and the Soviet Union, while at the same time engaging in the laboratory method and projection instruments of scientific management. This system, developed and applied throughout Yugoslavia, between 1957 and 1968, drew the attention of a group of artists and theorists, the New Tendencies Movement, who met biannually in Zagreb during this period, around a common interest in “programmed art” and, after 1965, computer art and architecture.

⁹⁰Through their visits and discussions of this project, this *late* and *peripheral* application of scientific management to modernist architectural practice entered into the emerging discourse of computer art and architecture.⁹¹

⁹⁰ Margit Rosen, ed. *A Little-Known Story About a Movement, a Magazine, and the Computer's Arrival in Art: New Tendencies and Bit International, 1961--1973* (Cambridge: The MIT Press, 2011).

⁹¹ These architects were educated at the University of Zagreb, during the early 1950s. Through lectures there and as part of that city’s culture they were exposed to the ideas of Hermann Muthesius, the early editions of the *Oeuvre Complete*, which still included the complete laboratory in Bordeaux, as well as the work of the RFG.

Chapter 1. Theorizing the Laboratory Method: Frederick Taylor and Hermann

Muthesius, 1900-1920

This chapter will focus on the laboratory method, a *general way of viewing the space of production* as a space of inquiry, which distinguished scientific management from other forms of industrial management during the first decades of the twentieth century.⁹²

Emphasis on and application of the laboratory method was not universal among the members of the Taylor Circle, or proponents outside of it, nor would it be among those European modern architects that discussed scientific management in their own writings.⁹³

(Fig. 01, 02) Nevertheless, Frederick Taylor, Henry Gantt, and Frank and Lillian Gilbreth, as well as proponents outside of the Circle, such as Henri Le Châtelier (1850-1936) in France and Aleksei Gastev (1882-1939) in the Soviet Union, saw the laboratory method as the essence of scientific management. Similarly, it would be central to the earliest discussions

⁹² Michael J. Piore used the phrase “general way of viewing the production process” in response to David Nelson’s new research on scientific management to imply that while scientific management may not constitute the fully formed ideology argued for by earlier critics, like Harry Braverman, it was also more than a “specific set of practices”. In his own discussion of scientific management, David Nelson often refers to Francis Copley’s biography on Taylor, as one of the more rigorous accounts of his work during the twenties. Nelson’s own discussion of what distinguished scientific management from other forms of modern management aligns with Copley’s notion of the “laboratory method”. While this term was never universal, all of the discussions of what differentiated scientific management that I will discuss here align most closely with Copley’s term. Copley described the “laboratory method” as a process that moved from “experimentation to standardization”. I will also use these two terms in this text and throughout the remaining chapters.

⁹³ Guillen already provides a good overview of when and where the first discussion of scientific management by architects occurred in Mauro F. Guillen, *Models of Management: Work, Authority and Organization in a Comparative Perspective* (Chicago: The University of Chicago Press, 1994). He provides an even more detailed account in *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture* (Princeton: Princeton University Press, 2006). In both books, the dissemination of the discourse of scientific management is mapped as opposed to the work of Daniel Nelson, where the application is mapped. I have used Nelson to further distinguish the mere mention of scientific management and the actual comprehension of its principles, as distinct from more general discussions of industry or industrial management. Andreas Schwarting has shown that this German architect found the “experimental settlements” program unnecessary, arguing that standards, which could be deduced rationally already existed, and were embodied in vernacular architecture. Andreas Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm* (Dresden: Thelem Universitätsverlag, 2010). A good example of a right-wing critique of the experimental settlements program is included in "Neue Baukunst Und Wohnungspolitik," *Wasmuths* 1 (January 1929). A more general discussion of this critique is also included in Schwarting,

of scientific management, in relation to modern architecture, by Peter Behrens, Le Corbusier and Hermann Muthesius⁹⁴, and would appear in later discussions by Martin Wagner, Walter Gropius and Ernst May.⁹⁵ While these architects never completely translated the principles of scientific management, many of which pertained more to the work of the contractor than to that of the architect, they all discussed how the laboratory method might be applied to architectural production, namely the production of drawing sets.⁹⁶ After 1920, Hermann Muthesius and Le Corbusier's translations of the laboratory

⁹⁴ Heinrich de Fries Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* (Berlin: Verlag der Bauwelt, 1918). Followed by Peter Behrens, "Die Gruppenbauweise," *Wasmuths* (1919). Amédée Ozenfant and Charles-Edouard Jeanneret, *Après Le Cubisme [After Cubism]*, Commentaries Sur L'art Et La Vie Modern (Paris November 15, 1918). Le Corbusier, "Maisons En Série," *L'Esprit Nouveau* 13(1922). Hermann Muthesius, "Der Typenbau (Type Building)," in *Kleinhaus Und Kleinsiedlung* (Munich: F. Bruckmann A.-G., 1920). "Wirtschaftliche Baubetriebsformen (Systematically Managed Building Methods)," in *Kleinhaus Und Kleinsiedlung* (Munich: F. Bruckmann A.-G., 1920). Much of the text, including passages that may have influenced Le Corbusier's 1920 text, was already included in an earlier 1918 edition. The most extensive discussion of the Behrens text thus far is included in Fritz Neumeyer, "The Workers' Housing of Peter Behrens," in *Industriekultur: Peter Behrens and the Aeg, 1907-1914*, ed. Tilmann Beddensieg in collaboration with Henning Rogge. The most recent discussion of Le Corbusier's early texts is included in Jean-Louis Cohen, "Introduction," in *Toward an Architecture* (Los Angeles: Getty Research Institute, 2007). The definitive discussion of Le Corbusier's relationship to scientific management is included in Mary McLeod, "'Architecture or Revolution': Taylorism, Technocracy, and Social Change," *Art Journal* 43, no. 2 (1983). The only discussion of *Kleinhaus und Kleinsiedlung* is included in Laurent Stalder, *Hermann Muthesius, 1861-1927: Das Landhaus Als Kulturgeschichtlicher Entwurf*. (Zurich: GTA Verlag, 2008). No specific discussion of the chapter on scientific management is included. The relationships between the three authors are extensively discussed in Stanford Anderson, *Peter Behrens and a New Architecture for the Twentieth Century* (Cambridge: The MIT Press, 2000). in Allen Brooks, *Le Corbusier's Formative Years* (University of Chicago Press 1999). And in Francesco Passanti, "The Vernacular, Modernism, and Le Corbusier," *Journal of the Society of Architectural Historians* 56, no. 4 (December 1997). The relationship between these three texts to one another, as well as to scientific management in general, has not been analyzed.

⁹⁵ Martin Wagner mentions Frederick Taylor and Frank Gilbreth in Martin Wagner, *Neubauwirtschaft* (Berlin: Karl Heymann, 1918). His first extensive discussion of the laboratory method is included in "Rationalisierter Wohnungsbau," [Rationalized Dwelling-building.] *Soziale Bauwirtschaft* 5, no. 20 (15 October 1925). Walter Gropius discussed Taylor and Gilbreth as early as 1926, with his most extensive article on the subject being Walter Gropius, "Erfolge Der Baubetriebsorganisation in Amerika," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Technische Tagung in Berlin / 15 bis 17. April 1929 (April 1929). Ernst May discussed his work through the discourse of scientific management in a series of articles in his magazine, *Das Neue Frankfurt*. Like Gropius, May's most extensive discussion of the topic came in 1929, after he had completed a significant portion of his "experimental settlement" at Praunheim. That discussion can be found in Ernst May, "Housing Policy of Frankfurt," *Das Neue Frankfurt* Special Edition (January 12, 1929). All three were familiar with the earlier writings of Peter Behrens, Hermann Muthesius and Le Corbusier on this subject, which I will discuss in this chapter. I will discuss their texts in Chapter 5.

⁹⁶ The industrial engineer prepared protocols and managed production with them – the architect often prepared protocols while the contractor managed production with them.

method would provide a disciplinary supplement to the various explanations of this approach that were already available.

The notion of the laboratory method developed through the work of Taylor and other members of the Taylor Circle, between 1901 and 1917. Although the approach was alluded to as early as 1895, and was presented, through lectures and demonstrations, at Bethlehem Steel in Pennsylvania and at the *Exposition Universelle* in Paris, between 1899 and 1901, Taylor did not provide a concise explanation of what would later be called the laboratory method until his publication of "Shop Management" in 1903.⁹⁷ While Taylor would always be acknowledged as the author of this method, his explanation was by no means the clearest or the most thorough. In America and Germany, Frank and Lillian Gilbreth's *Primer of Scientific Management*, which was first published in 1912 in America and in 1917 in Germany, was utilized more often in the application of these principles, even though Taylor's *Principles of Scientific Management* (1911) was more widely read.⁹⁸ In France, Henri Le Châtelier's 1914 article, "Le System Taylor", was also clearer and more concise than the French translation of *Principles*, for which Le Châtelier had written an introduction.⁹⁹ Nevertheless, these texts shared the same basic definition of the laboratory

⁹⁷ Frederick Winslow Taylor, "Shop Management," *Transactions of the American Society of Mechanical Engineers* XXIV(1903).

⁹⁸ Frank Bunker Gilbreth, *The Primer of Scientific Management* (New York: Norstrand, 1912). Frank B. Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*, trans. Colin Ross (Berlin: Julius Springer, 1921 (1917)). is much more than a revised edition and translation of *Primer*, including material from a number of other articles published before hand and even some material only published later, in America. It is likely that the Gilbreths were planning a more comprehensive American version of this publication before 1924 when Frank died, suddenly.

⁹⁹ Henri Louis Le Châtelier, "Le Système Taylor," *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* 113(March 1914). The article was republished in Le Châtelier, *Le Taylorisme* (Dunos, 1928). For a discussion of his importance in France and in Europe, see David Nelson, "Introduction," in *A Mental Revolution: Scientific Management since Taylor* ed. David Nelson (Columbus: Ohio State University Press, 1992). Châtelier made excuses for Taylor's own vagueness in this article and also included parts of two articles by Frank and Lillian Gilbreth and Henry Gantt, providing one of the most thorough explanations of scientific management, and particularly the laboratory, or as he called it, the "experimental method" of

method, one that was more attributed to Taylor's work than his discourse, and one that would inform the most definitive explanation of this approach by Francis Copley, in 1922, two years after Le Corbusier and Hermann Muthesius had provided their interpretations of the laboratory method for modern architecture in French and German. For these reasons, I will analyze explanations of the laboratory method provided by Frederick Taylor, Frank and Lillian Gilbreth and Henri Le Châtelier, authors whose work was certainly known by modern architects before 1918¹⁰⁰, as well as lesser known sources, such as Horace Drury's overview of the approach in 1915, in the first dissertation on the subject, Daniel Hauer's 1918 discussion of scientific management and construction management, Francis Copley's definitive 1922 text on the laboratory method, and Aleksei Gastev's explanation of the laboratory method, as viewed from within the context of the Soviet Union, in 1929, at the end of my period of study. While the authors' varying backgrounds caused them to not only stress different aspects of the laboratory method, but to apply its principles in significantly different ways, they nevertheless agreed on a common definition and source. Likewise, the architects whom first discussed scientific management and the laboratory method, Peter

industrial organization, available anywhere at that time. While Le Corbusier never cited his own sources, his discussion of Taylor's work suggests a knowledge of this source, as well Frederick Winslow Taylor, *Principes D'organisation Scientifique Des Usines* [The Principles of Scientific Management], trans. J. Royer (Paris: Dunod & Pinat, 1911). Le Châtelier wrote the introduction to the French translation.

¹⁰⁰ There are a number of phases of dissemination of scientific management to Europe. The first, starting around 1900, consisted of European engineers visiting America, hearing Taylor or other members of the Taylor Circle lecture, or through reading original or translated versions of key publications. After 1910, the publication and translation of *Principles*, as well as number of highly publicized strikes in America and France, between 1910 and 1913, led to a more general interest in scientific management outside of the engineering fields. By 1914, most European newspapers had used the term *Taylor-System* or *Taylorisme*. Between 1914 and 1920, more detailed manuals were made available, and were now being written by European engineers, many of who had had their own experiences applying this approach in a very different context. Between 1918 and 1920, the three architects I will discuss provided a more disciplinary explanation of scientific management. Between 1920 and 1926, more detailed discussions of scientific management applied to architecture and urbanism, began to appear, especially in Germany. Between 1926 and 1930, these publications increased, again, especially in Germany. For a general overview of these phases, see Nelson, "Introduction."

Behrens, in March 1918, Le Corbusier, in November 1918 and Hermann Muthesius, in 1920, were no different. In all three of these early discussions, the theoretical discourse regarding the nature of type in architecture, which developed through the course of the 19th century and was debated for seven years at the meetings of the *Deutscher Werkbund*, in which all three of the authors participated, directly informed the discussion of the laboratory method. I will argue that the particular definition of type offered by Hermann Muthesius, and developed during the same period as scientific management, 1901-1917, deeply informed the translation of the laboratory method to architectural production by that architect in 1920, as well as by Le Corbusier, in 1918 and especially in 1920, just as the absence of this notion of type in Peter Behrens' discourse limited his translation and later application of scientific management's central ontological theory.

The Evolution and Formulation of the Laboratory Method, 1901-1920

In May 1900, Frederick Winslow Taylor, the "father of scientific management", literally exploded onto the scene in a cloud of sparks, metal shavings and propaganda at the *Exposition Universelle* in Paris.¹⁰¹ Bethlehem Steel, the American foundry for whom Taylor, and a team of associates, had been working for as a consulting engineer since 1898, had unintentionally provided him with his first opportunity to present his theories and methods of industrial organization to an international audience.¹⁰² Bethlehem's board of

¹⁰¹ The *Exposition Universelle* of 1900 was held in Paris from April 15 until November 12. The growing importance of American industry was reflected in the fact that American machine tool manufacturers were designated their own pavilion, near the Bois de Vincennes.

¹⁰² Taylor's appearance in Paris was the first presentation of his particular approach to industrial production. The terms "scientific management" or "Taylorism" would not appear until much later. His work at Bethlehem Steel was already attracting attention from European engineers, who visited the factory during his consulting work there. For a detailed account of Taylor's presentation in Paris see Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (Cambridge, MA: The MIT Press, 1997), 336-43. For more on the early interest in Taylor's work on the part of the AEG, one of the first firms to adopt his principles, see Henning Rogge, "A Motor Must Look Like a Birthday Present," in *Industriekultur: Peter Behrens*

directors had hired Taylor for two specific reasons: first to implement his “A Piece Rate System” of worker compensation, and second to support his and J. Maunsell White’s, an associate of Taylor, work on high speed steel tools, which they had started at a smaller foundry, Midvale Steel.¹⁰³ Taylor, an independently wealthy member of Philadelphia’s “Quaker Aristocracy”¹⁰⁴, had sought out Bethlehem Steel as a site for a “series of experiments”. Much to the employer’s dismay, these experiments were first and foremost focused on developing a complete form of industrial organization and only partially interested in increasing efficiency and profitability.¹⁰⁵ Not surprisingly, these different priorities created tensions throughout Taylor’s employment and ultimately led to his termination from Bethlehem in 1901. In 1903, he would proudly boast that his discovery of the “Taylor-White process of treating tool steel”, an invention that to the manufacturing community was analogous in significance to Edison’s light bulb or Ford’s Model-T, was simply a byproduct of his experimental derivation of “standard(s) for the Bethlehem

and the Aeg, 1907-1914, ed. Tilmann Beddensieg in collaboration with Henning Rogge (Cambridge: The MIT Press, 1984), 105.

¹⁰³ Taylor’s first important article, “A Piece Rate System: A Step Toward Partial Solution of the Labor Problem” was presented to the annual meeting of the American Society of Mechanical Engineers in 1895, and published later that year in their proceedings. While certainly not even a “partial” solution to labor relations, Taylor’s dedication to deriving and tracking data not usually analyzed in industrial production impressed his colleagues. David Nelson has shown that the owners of Bethlehem Steel assumed that Taylor’s primary role would be the introduction of this wage scheme. Instead, he attempted to reorganize a significant portion of this large facility, dealing with this wage system at the end of his tenure there. This disjunction between Taylor’s priorities and those of his client led to him being fired in 1901. For more on Taylor and Bethlehem Steel see Daniel Nelson, “Taylorism and the Workers at Bethlehem Steel, 1898-1901,” *The Pennsylvania Magazine of History and Biography* 101, no. 4 (1977).

¹⁰⁴ For more on Taylor’s background see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 10-60.

¹⁰⁵ Henry R. Towne, the father of systematic management, the precursor of scientific management, and author of the first article defining what would become the sub-discipline of industrial engineering, “Engineer as Economist” (1886), called Taylor’s work at Midvale and Bethlehem Steel a “series of experiments” in an extensive foreword to the republication of Taylor’s book-length article, “Shop Management”. First published in 1903, this foreword, which was included in later translations of the book in Europe, summarized the principles of scientific management through examples of Taylor’s work at Midvale Steel and Bethlehem Steel, much more clearly than Taylor himself. Frederick Winslow Taylor, *Shop Management* (New York: Mc Graw Hill, 1911), 6-11.

works".¹⁰⁶ The tool, and even the industrial plant itself, were secondary in significance to the organizational and, more importantly, ontological principles with which it was developed; those principles, first published in the 1903 article, "Shop Management", were the mechanics behind the fantastic display at the American manufacturers pavilion in Paris in 1900. Just as Taylor had essentially co-opted the foundry, including both its employees and thousands of pounds of metal for his own experiments, he also convinced his employer to transplant a portion of the Pennsylvania foundry to the Continent, at great cost and significant delay.¹⁰⁷ While the other exhibitors represented their approaches to industrialization through static products and charts, Taylor and his associates presented their work in real time, granting Bethlehem a banner ad. Visitors not only witnessed the impressive speeds with which the Taylor-White tools cut through various metal alloys, but moreover they were exposed to Taylor's theories, both resultant of the scientific method superimposed into the space of industrial production. The tools, and more importantly the exact speed and motions of their use, were the byproduct of this new approach, with the demonstration itself continuing this process of standardization, ad infinitum.

In "Shop Management", Taylor described his approach both as a "systematic and scientific time study" and the "slow and difficult process of trial and error", which, more than immediate efficiency, yielded "exact information" and "data".¹⁰⁸ Initially, Taylor was reluctant to describe his management approach as scientific, explaining that while "(m)odern engineering can almost be called an exact science", management, the planning

¹⁰⁶ Ibid., 124. Nelson's research corroborates Taylor's claims.

¹⁰⁷ In sharp contrast to the promise of efficiency and social equilibrium, achieved with minimal expense, made to his clients, Taylor boasted in both "Shop Management" and *Principles of Scientific Management* (1911) of the vast resources he had expended in his experimentation and standardization, at the client's expense.

¹⁰⁸ Taylor, *Shop Management*, 25-26.

and coordination of production processes, remained “more of an art”. However, while this process remained an art, it could at least now be informed by data which had been experimentally derived on site, instead of by the “rule of thumb” of existing management, or a “subject to be theorized over”, by owners and “college men” who lacked practical experience.¹⁰⁹ It would be Louis Brandeis (1856-1941) who concluded that a management founded on data developed “scientifically”, in other words through a method of trial and error, could and should be called “scientific management”, a term that Taylor accepted in 1911, four years before his death.¹¹⁰ Even in his most propagandistic publication, *The Principles of Scientific Management* (1911), he oscillated between the idea of “management [as] a science”, where the term scientific was limited to the “study and analysis of the methods and implements in use, together with accurate, minute, motion and time study”, and that of management as art, where scientifically derived standards could not prevent “failure and disaster”.¹¹¹ While Brandeis, as well as a number of other well-intentioned promoters of scientific management, tended to diminish this caveat, most of Taylor’s disciples would share, and even exceed Taylor’s cautiousness in labeling any management as having the potential to be scientific. Rather, they shared his goal of bringing the scientific method into the space of production, while simultaneously acknowledging, to varying degrees, just how feasible the fusion of the spaces of production and inquiry, the factory, the construction site, and the laboratory, could actually be. It would be these practitioners,

¹⁰⁹ Ibid., 63-64.

¹¹⁰ Louis Brandeis was a lawyer, an associate justice on the Supreme Court (1916-1939) and a leading figure of the Progressive movement. He saw scientific management as a potential tool in the fight against monopolies, hoping to use more specific, data driven parameters to regulate the costs of certain services. Brandeis pushed Taylor to consider the translation of his principles from the industrial plant to governance. For more on this see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 429-35.

¹¹¹ Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper, 1911), 128-29.

and not Taylor himself, who would most clearly explain his approach, and while they consistently referred to the overall methodology as either the Taylor System, before 1914, or scientific management afterwards, each would label the experimental derivation of standards differently; in interwar America, common terms were the “laboratory method” or “idea”¹¹², in Germany, where the most influential manual on scientific management was prepared by Taylor’s associate, Frank Bunker Gilbreth (1868-1924), in collaboration with his partner Lillian Moller Gilbreth (1878-1972), the direct translation *Laboratorium Idee*, was common¹¹³, while in France Henry Louis Le Châtelier (1850-1936) preferred the expression, “*méthode expérimentale*”¹¹⁴, from which the Russian equivalent, “*eksperimental'naya moment*” was based.¹¹⁵

Taylor’s relatively vague accounts, which his most vocal French advocate, Le Châtelier explained as a reflection of the Americans “temperament, passion for action, ... contempt for chatter, and disdain for prose”, arguably led to the “misunderstanding” of scientific management and its equation with “simple incentive schemes” and “ways to speed up work”.¹¹⁶ But while Taylor’s records lacked thorough explanation, further work

¹¹² Frank Copley first used the term in 1923 to describe the most important aspect of scientific management. Frank B. Copley, *Frederick W. Taylor: Father of Scientific Management* (New York 1922). Lillian Gilbreth referred to the same basic principles as the “laboratory idea” in her biography of her recently deceased husband and partner. See Lillian Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth* (Society of Women Engineers, 1990 (1925)), 33.

¹¹³ Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*.

¹¹⁴ Châtelier, “Le Système Taylor.”

¹¹⁵ Aleksei Gastev, “Organizatsiya Proizvodstva Kak Nauka,” *Tsentral'nyy institut Truda* (1929). Republished in *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda* (Moscow: TsIT, 1966). Gastev had first been exposed to scientific management in France, in 1912. Throughout the first half of the twenties, he maintained an active correspondence with Frank Gilbreth. For more on Gastev see Kendall E. Bailes, “Alexei Gastev and the Soviet Controversy over Taylorism, 1918-24,” *Soviet Studies* XXIX, no. 3 (1977).

¹¹⁶ Châtelier, “Le Système Taylor,” 83-84. He excuses Taylor’s own lack of clarity by stating: “L'Américain a, par tempérament, la passion de l'action, mais aussi le mépris du bavardage. Il lui suffit de faire oeuvre utile; à quoi bon perdre son temps à expliquer par le détaille résultat de ses efforts?” He also complains of a superficial understanding of his principles: “L'importance du système Taylor a été longtemps méconnue; on y vit d'abord un simple système de primes visant à stimuler l'activité des ouvriers plus récemment on s'est efforcé de le réduire au chronométrage, procédé de mesure depuis longtemps connu d'ailleurs et

completed by his associates, as well as individuals in America, France, Germany, and the Soviet Union, drew similar conclusions, often independently of one another, based partially on Taylor's writings, as well as on their own experiences.

In contrast to later characterizations of scientific management, which often emphasized Taylor's criticism of "rule-of-thumb" methods, these accounts equally stressed his critique of a purely deductive or rationalistic approach to industrial organization. The fact that Taylor had eschewed a Harvard education for a traditional apprenticeship, having held the "various positions of foreman, master mechanic, chief draftsman, chief engineer, general superintendent, general manager, auditor, head of the sales department", as well as more menial positions, was often referenced in later accounts of scientific management and this trajectory of inquiry was even duplicated by some associates, most notably Frank Bunker Gilbreth.¹¹⁷ The industrial vernacular itself was to be studied, but the "traditional or unsystematized" mode of management, with its lack of "records" and "investigations" needed to be replaced, just as "systematic management", which relied primarily on deductively or rationalistically derived standards, needed to "remedied" through the introduction of on-site experiments.¹¹⁸

constamment employé dans les usines. S'il fallait tenir pour exacts ces points de vue particuliers, rien ne justifierait le bruit fait autour de l'organisation scientifique du travail, ce serait là un système dépourvu de nouveauté et médiocrement intéressant."

¹¹⁷ Taylor, *Shop Management*, 185. After completing his schooling at Exeter, in 1875, Taylor applied to and was accepted to Harvard University but decided to pursue an apprenticeship as a tool pattern maker in Philadelphia, between 1876-1878. For more on this see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 75. Frank Gilbreth would follow a similar course of education, abandoning plans to attend MIT for an apprenticeship as a bricklayer. For more on this see Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth*, 14-15. This kind of attitude appealed to European modernist architects raised on romanticism's critiques of Academicism, especially those with no formal academic training.

¹¹⁸ In "Shop Management" the same principles were presented as a part of systematic or simply modern management. While the principles remained essentially the same, the distinction between traditional or systematic management and scientific management came in *Principles*. Taylor, *The Principles of Scientific Management*, 23-24. For more on this see Daniel Nelson, "Scientific Management, Systematic Management,

The importance of site specificity was frequently emphasized, with Taylor explaining in 1903 that the “application of the underlying principles must be modified to suit each particular case,” and in 1911 that the “same mechanism will in one case produce disastrous results and in another, the most beneficent.”¹¹⁹ His closest associate in his work at Midvale and Bethlehem Steel, Henry L. Gantt, boldly stated, “there are as many distinct scientific managements as there are different shops”.¹²⁰ Even more explicit in his defense of the site-specific derivation of standards was Daniel J. Hauer, an American engineer and economist working in construction, who argued:

One may, if he chooses, use the results of another's experimentation as a basis for his own cutting and trying; but unless he goes further, and applies the cut-and-try expedient to his newfound knowledge, he becomes, not a scientific manager, but merely an imitator. ... There are all sorts of cutters and *tryers*, varying from men whose intuitions have all the earmarks of inspiration, down to those who cut their eyeteeth in trying to learn scientific management out of a book. Scientific management involves much more than the formulation of standards. It comprehends the repudiation of standards. It demands the setting aside of preconceived notions and fixed ideas regarding business.¹²¹

While Hauer was more explicit in his discourse, Taylor's own experiences, his basic theories, if not always the accounts of his own work, suggested similar conclusions.

and Labor, 1880-1915," *The Business History Review* 48, no. 4 (Winter, 1974). For a history of systematic management's shift from the railways to factories see Jo Anne Yates, *Control through Communication: The Rise of System in American Management* (Johns Hopkins Press, 1989).

¹¹⁹ Taylor, *The Principles of Scientific Management*, 128.

¹²⁰ Horace Drury quoted Gantt in the first dissertation on scientific management. He also included a diagram showing how Taylor deals with problems, by plowing through them, while Gantt is more open: “Sometimes, indeed, Gantt does not reach his original goal, but decided on a new one.” The significant differences in approach may explain Gantt's greater success in the installation of scientific management while at the same time following the same “laboratory method” as Taylor. Horace Bookwalter Drury, “Scientific Management: A History and Criticism” (Columbia University, 1915), 95-96.

¹²¹ Daniel J. Hauer, *Modern Management Applied to Construction* (New York: McGraw Hill, 1918), 2. By the time Hauer published this book, Gilbreth had been out of the construction business for nearly a decade. Just as Gilbreth's *Primer of Scientific Management* (1912) was a more clear and thorough explanation of Taylor's ideas, deviating in some places while at the same time maintain the basic principles of the laboratory method, experimentation and standardization, Hauer's book summarized Taylor and Gilbreth's work more clearly, filling in certain areas, emphasizing certain points, all the while retaining the basic arguments.

The Tentative Standard, Frederick Taylor and Scientific Management

Taylor's own work in the experimental derivation of standards alluded to an inherent conflict of interest between that of plant owner and consulting manager, whose experiments would undoubtedly require the extensive use of plant resources. Within his own experiments, Taylor inventoried an astounding "26 years", "30-50,000 experiments", "800,000 pounds of steel", "100-200,000 dollars" and "thousands of pages", the majority of which being at the blind expense of the owners themselves.¹²² Again, many of the later proponents of scientific management more directly acknowledged this problem. "The benefits of the scientific method of experimentation are obvious", stated Le Châtelier, "but what about the cost of doing experiments", especially when Taylor's writings had now boasted of the astounding consumption of resources and time that a complete "installation" of scientific management would require?¹²³ The French metallurgist pointed to Taylor's success not only in exhaustive material trials, but also in "qualitative research of factors of a given phenomenon", which were "inexpensive and relatively simple to perform."¹²⁴ While

¹²² Taylor peppered "Shop Management" and *Principles* with these kinds of figures, emphasizing the iterative nature of his work, as well as the authority of his approach. David Nelson and Robert Kanigel have both found that Taylor frequently returned to data, collected from his earlier work at Midvale Steel, during the 1880s, in his later work. Whether or not all of his conclusions were "one best practices" they certainly reflected an extraordinary dedication to trial and error, with Taylor paying significant premiums to the operators he worked with and happily expending the equipment and raw materials of his clients, most of whom had little interest in or even knowledge of his experimental work.

¹²³ "Les avantages de la méthode expérimentale scientifique sont évidents; mais ne coûtent-ils pas trop cher; rapportent-ils, comme abaissement du prix de revient et comme amélioration de la qualité, plus qu'ils ne coûtent?" Le Châtelier was also clear that "L'étude de tous les problèmes industriels peut et doit être faite à l'usine par les méthodes de la science expérimentale" was the single most distinctive characteristic of "le scientific management". Le Châtelier, "Le Système Taylor," 85-86.

¹²⁴ "La recherche qualitative des facteurs d'un phénomène donné est une opération relativement simple ou, plus exactement, peu dispendieuse à exécuter. Pour y voir clair, il faut de l'esprit d'observation, du jugement, mais il n'y a pas besoin d'appareils compliqués, de main-d'oeuvre coûteuse." Ibid., 86. Le Châtelier's willingness to exchange observation for experiment certainly helped to encourage readers, like Le Corbusier, to apply this method to a broad set of tasks, but it also veers close to what Peter Galison has defined as the core fallacy of Positivism in the sciences, technical fields and even architecture during this period. For more on this see Peter Galison, "History, Philosophy, and the Central Metaphor" *Science in Context* 2(1988): 197-99.

Taylor's significant personal wealth allowed him to induce workers to participate in his experiments primarily through cash payments, he himself did acknowledge other approaches, encouraging managers to alternatively elicit suggestions from workmen, with the management making a "careful analysis of the new method, and if necessary conduct a series of experiments to determine accurately the relative merit of the new suggestion and of the old standard." If the "new method (was) found to be markedly superior to the old, it (would) be adopted as the standard for the whole establishment", and the workman would be "given full credit for improvement".¹²⁵ Here, Frank, and particularly Lillian Gilbreth, a trained psychologist, would excel, calling managers to realize that the "worker is of an inquiring mind, and unless this inquiring tendency is recognized, and his curiosity satisfied, he can never do his best work". Lillian clearly stated what Taylor himself had done, but did not adequately acknowledge, namely that "scientifically derived standards" were "founded on [the] experience" of various individuals.¹²⁶

¹²⁵ Taylor, *The Principles of Scientific Management*, 128. In practice Taylor often paid for these improvements, without crediting their authors. Henry Gantt practiced this principle more consistently, often to the displeasure of Taylor, and developed an early version of the gantt chart to formalize what for Taylor was more of an informal system. Gantt discussed this in detail in Henry L. Gantt, "A Graphic Daily Balance in Manufacture," *Transactions of the American Society of Mechanical Engineers* XXIV(1903). David Nelson's research supports Gantt's claims regarding the application of this approach, Nelson, "Taylorism and the Workers at Bethlehem Steel, 1898-1901." A similar approach was advocated and practiced by Frank and Lillian Gilbreth, with new standard methods being named after the operator or manager who invented them. For more on this see Brian Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940." (Purdue University, 1987). Both Gantt and the Gilbreths attributed this approach to Taylor.

¹²⁶ Lillian Gilbreth, "The Psychology of Management1--Ix: Teaching, under Scientific Management," *Industrial Engineering and the Engineering Digest* XIII no. 1 (1913): 19-21. The critics of scientific management often argued that Taylor's experimentally derived standards were invalid because of his lack of training in psychology or sociology. This is certainly valid when considering his wage systems, particularly in relation to his promise of better labor relations. Lillian Gilbreth, on the other hand, was one of the few formally trained industrial psychologists working in industry at that time, male or female, with degrees from UC Berkley, Columbia University and Brown University, where she finally received her doctorate in 1915. While scholars have dually noted patristic tendencies in some of her work, those tendencies were wide spread during this period, among scholars and practitioners. Both Taylor and the Gilbreths used the same laboratory method approach, with different skill sets and ideological, even aesthetic sensibilities, which in turn yielded different results whose processes were nevertheless scientifically managed. For more on Lillian Gilbreth see Jane

It would be the Gilbreths that would most explicitly define what the notion of a standard entailed for scientific management. Lillian often argued that all “systems ... being written ... have all the disadvantages of anything that is written”, namely that they “require considerable adaptability on the part of the man who is using them.”¹²⁷ In her own discussion of the *laboratory idea* she referenced her partner’s early acknowledgement of the contingency of standards starting in 1908 with his first construction manuals, where experiments were staged both to assist in “the work in hand”, as well as to achieve a “gradually standardized type of material for future use.”¹²⁸ In the introduction to the first of those manuals, *Concrete System* (1908), Frank Gilbreth explained that the work was not a “text-book or treatise”, instead emphasizing the work’s provisional nature, with the standards, or “rules” as he still called them, reflecting the “ideas of the most successful men in our organization” and that were derived “from our own works exclusively”.¹²⁹ He also explained that these “rules” should be “added to and modified whenever our advancing

Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond "Cheaper by the Dozen"* (Boston: Northeastern University Press, 2006).

¹²⁷ Gilbreth, "The Psychology of Management1--Ix: Teaching, under Scientific Management," 21.

¹²⁸ *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth*, 33.

¹²⁹ Frank Bunker Gilbreth, *Concrete System* (New York: The Engineer News, 1908), 2-3. Tom Peters distinguished Gilbreth’s manual from the numerous publications on concrete construction available at that time due to its focus on “practical experience” and “methods” instead of “material and structural issues”. For more on this see Tom F. Peters, *Building the Nineteenth Century*: (Cambridge: The MIT Press, 1996), 92-94. Gilbreth provided a detailed discussion of a new drawing type, the construction plant plan, a projection that considered the static structure of a building along with the changing positions of materials and equipment. Gilbreth’s rival for Taylor’s approval, Sanford E. Thompson, an MIT-educated civil engineer, had published a survey of factory projects that were beginning to experiment with this method a year earlier. This case study approach, which included examples managed and built by Gilbreth, Thompson, as well as Albert Kahn, did not fully explain the new method. Sanford E. Thompson, *Reinforced Concrete in Factory Construction* (New York: The Atlas Portland Cement Company, 1907). Thompson had worked with Taylor on Frederick W. Taylor and Sanford E. Thompson, *A Treatise on Concrete, Plain and Reinforced* (New York: John Wiley & Sons, 1905). *Concrete System* attracted much more attention from modernist architects, precisely because it dealt more with spatial and temporal planning than with structural or material properties. Martin Wagner translated and summarized the approach in an article, Martin Wagner, "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert," [How an American Contractor Promoted Systematic Management.] *Soziale Bauwirtschaft* 5, no. 3 (1 February 1925).

experience shows this to be necessary”.¹³⁰ Four years later, and no longer a contracting but a consulting engineer, Gilbreth would similarly define the “standard”, or the product of the “laboratory method”, in his highly influential *Primer of Scientific Management* (1912):

A standard ... is simply a carefully thought out method of performing a function, or carefully drawn specification covering an implement or some article of stores or of product. The idea of perfection is not involved in standardization. The standard method of doing anything is simply the best method that can be devised at the time the standard is drawn. Improvements in standards are wanted and adopted whenever and wherever they are found. There is absolutely nothing in standardization to preclude innovation. But to protect standards from changes which are not in the nature of improvements, certain safeguards are erected. These safeguards protect standards from change for the sake of change. All that is demanded under modern scientific management is that a proposed change in a standard must be scrutinized as carefully as the standard was scrutinized prior to its adoption... Standardization practiced in this way is a constant invitation to experimentation and improvement.¹³¹

In 1922, Gilbreth would further refine his theory of standards and standardization, distinguishing between the typical standard of scientific management, the “tentative standard”, and something he called the “superstandard”, a standard which had been found to be valid for use in various industries.¹³² While clearer than Taylor, Gilbreth’s own

¹³⁰ Gilbreth, *Concrete System*, 171-72.

¹³¹ Here Gilbreth was actually quoting another member of the Taylor Circle, Morris Llewellyn Cooke’s “Report to the Carnegie Foundation For the Advancement of Teaching”, prepared the previous year. *The Primer of Scientific Management*. In 1914, the manual was slightly expanded and republished in English, including material never published in America in Germany in 1917. Lillian, a fluent German speaker, oversaw the translation of the manual. Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*. Due to demand, this manual was republished frequently, between 1917 and 1923, placing Gilbreth on equal footing with Taylor in terms of influence in the German context.

¹³² Frank and Lillian Gilbreth, "Superstandards: Their Derivation, Significance and Value," *Bulletin of the Taylor Society* VII, no. 3 (June 1922). This article was initially presented as a paper at a meeting of the Taylor Society in Philadelphia on March 17, 1922. In the paper, Gilbreth praised the work of the German engineer society, the *Verein Deutscher Ingenieure* (VDI), for lobbying for the formation of the *Normenausschuß der deutschen Industrie* (NADI), or “Standardization Committee of German Industry”, in 1917. The committee changed its name in 1926 to the *Deutscher Normenausschuß* (DNA), or “German Standardization Committee”, reflecting its expansion out of the factory. The non-governmental agency collected tentative standards from various industries, before issuing standards that might apply to multiple industries, called DIN-Norms, short for German Norms. These standards, which included A4 Paper, were not obligatory regulations, although regulations would use them as references. Gilbreth had purchased a number of DIN-Norms, as well as equivalents from programs developed in Holland and Sweden, included in "Flga Box 129 Folder 0926." I will

theories of standardization were rooted in Taylor's earlier writings, where he explained that when the "experimenter ... find(s) himself face to face with the problem as to whether he had better make immediate practical use of the knowledge which he has attained" through experimentation, "or wait until time positive finality in his conclusion has been reached", he advocated that it was "wise to put one's conclusions as soon as possible to the rigid test of practical use."¹³³ Here again, it would be Henry Gantt, not Taylor, who would take this statement to its logical conclusion, developing his "graphic daily balance", now known and still widely used as the gantt chart, in order to extend the experimental derivation of standards from more controlled studies, into the collective every day work of a typical space of production. However, it would be Hauer, not Gantt, who would add to this process the "constant comparison of actual performance with the standards to see that actual reaches the standard" but also to assist in the "repudiation of standards".¹³⁴

Even within Taylor's work, two distinct types of "installations" of scientific management can be identified.¹³⁵ First, were those where the installation was more productive in terms of generating what Gilbreth would later call *superstandards*. Alternatively were those where already experimentally derived standards were adjusted to a particular industrial plant, resulting in increased economy and efficiency, as well as

discuss this program later in this chapter and, in greater detail, in Chapter 5. Peter Behrens and Hermann Muthesius both wrote enthusiastically about this program in 1920, when it turned its focus to building-related norms.

¹³³ Taylor, *The Principles of Scientific Management*, 116. By "practical use" Taylor was referring to the application of experimental standards on the shop floor, within the space of the same plant where the experiments had been conducted.

¹³⁴ Hauer, *Modern Management Applied to Construction 2*.

¹³⁵ Taylor began using this term to describe the application of his, or any other organizational system to a particular site in *Principles*. The term appears widely in Frank Gilbreth's *Primer* (1912) and in all subsequent literature. The process of installing an operating system, as well as "programing" in computer science, is linguistically and procedurally rooted in this earlier concept, as Norbert Wiener later acknowledged. Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society*, Da Capo Series in Science (Boston: Houghton Mifflin Company, 1954 (1950)), 150.

improved labor relations, not only during the process of “installation”, which often lasted multiple years, but afterwards as well. For Taylor, Midvale Steel, where he had apprenticed and worked between 1878 and 1890, and Bethlehem Steel, where he had worked between 1898 and 1901, were incredibly successful in terms of experimental standard derivation, but less so in terms of standardization or in the permanent installation of systematic management or the laboratory method of scientific management.¹³⁶ This can be contrasted to later work at Tabor Tools and Link-Belt Co., where his close associates, such as H. K. Hathaway, carefully adapted already defined standards for specific use in these plants, which were met with general enthusiasm from the owners, the management and most workers, many of whom filled newly defined middle management roles, and the maintenance of a continual, albeit subtle, process of standardization after the consulting engineers had left the plants.¹³⁷ In Frank Gilbreth’s case, this trend occurred in reverse. The

¹³⁶ The implementation and extension of Taylor’s principles at these sites generated, both through experimentation and the application of the work to everyday production, high-speed steel tools, the slide rule, which was developed in collaboration with Carl Barth, and the gantt chart, developed by Henry Gantt. However, these plants were failures in that neither maintained the systems after Taylor left. For an extensive discussion of Taylor’s work at Midvale Steel see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 131-214. Taylor had less tension with the ownership of Midvale, primarily because he was a full time employee and fulfilled his duties, using his own funds to carry out his experiments. In a number of consulting jobs between Midvale and Bethlehem he was not even able to secretly conduct his experimental work. At Bethlehem, he was able to conduct experiments for a brief period before the ownership noticed that he was not doing what he had been hired to do, which was to apply a standard incentive wage scheme, not engage in experimentation and standardization. For more on this see Nelson, "Taylorism and the Workers at Bethlehem Steel, 1898-1901." Kanigel, following and expanding on Nelson’s research, comes to essentially the same conclusions.

¹³⁷ Working as a consulting engineer for both of these companies, Taylor installed many of the core principles of systematic management that were not already in place, and was also able to experimentally derive and further standardize custom protocols and parameters for these plants. Here he achieved efficiency, with profits increasing 2.5 times, and social equilibrium, expanding the ranks of the current management by training and promoting laborers from within the company. For more on this see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 394-96. Although most engineers interested in scientific management studied Tabor’s organization, in situ and through articles on the installed principles of scientific management written by others, Taylor and his later critics preferred to focus their discussion on the more dramatic work at Bethlehem Steel. For Taylor, Midvale and Bethlehem were more innovative and exciting experiences. Nevertheless, he experimentally derived two important new instruments at Tabor, the Taylor Flying Machine, a mechanized instruction card filling system with all of the basic features of an early

translation and application of scientific management first occurred between 1898 and 1908 within the framework of his contracting business, resulting in a balance between efficiency and economy and the experimental derivation of new standards.¹³⁸ Alternatively, his own shift to consulting for manufacturing plants, encouraged both by Taylor and Lillian, was marked by the successful experimental derivation of what could be called “superstandards” and an overall lack of success in achieving efficiency and economy for the plants that had hired him. The somewhat conflicted goals between achieving efficiency and economy in a given plant versus developing new standards in situ, which could be made generally applicable, can be detected in much of the scientific management literature. Drury stated somewhat dismissively that the “real emphasis” of Gilbreth’s work is that he “started out in the first place with the object of devising new and better methods, and that his introduction of management features like the task and bonus system was chiefly to secure obedience to directions”.¹³⁹ While more recent scholarship of Taylor’s own work suggests that such a characterization could easily be applied to him, Drury’s implication primarily diminishes the importance of the bricklayer-turned-contractor-turned-consulting engineer who had fallen out of favor with Taylor, as well as his more orthodox followers,

hard drive, and the Taylor Tool Grinder, an accessory for his high-speed steel tools. I will discuss both in Chapter 2.

¹³⁸ Gilbreth’s contracting business, active from 1895 until 1912, when he and Lillian decided to focus primarily on research and consulting for industry, was one of the larger and more innovative entities of its kind, working through the United States, Canada and England. While Taylor and Gantt almost exclusively worked as consulting engineers, Gilbreth was unique amongst the Taylor Circle for owning his own business before shifting to becoming a consultant, in 1912. The only extensive analysis of this important distinction is included in Price, “One Best Way: Frank and Lillian Gilbreth’s Transformation of Scientific Management, 1885-1940. .” Even here, the industrial work is the primary focus. Tom Peters’ shorter but more insightful treatment of this subject is the most extensive published account to date. For more on this see Peters, *Building the Nineteenth Century*.

¹³⁹ Drury, “Scientific Management: A History and Criticism,” 109. Drury’s tone reflects the general fear among *scientific managers*, including Taylor himself, that their work would be seen as focused more on exploration than problem solving.

particularly Sanford E. Thompson, an MIT-trained civil engineer, who tended to present scientific management in more deterministic and rationalistic terms.¹⁴⁰

While the laboratory method was widely discussed by Taylor, his associates and ardent admirers outside of the Taylor Circle, first in France, and later in Germany and the Soviet Union, it was installed only in a limited number of instances, primarily in small to medium sized privately owned enterprises in the United States, with a few significant exceptions.¹⁴¹ In 1913, while consulting for two industrial plants in New England, Frank Gilbreth also began consulting for *Auergesellschaft*, a medium sized German manufacturer based in Berlin, and Carl Zeiss, then based in Jena; these would constitute the only international, as well as the only cooperatively owned, plants where scientific management was installed by a member of the Taylor Circle.¹⁴² While smaller firms tended to apply various standard tools and methods attributable to the Taylor Circle, they did not engage in the experimental derivation of standards, whereas larger firms, including the Ford Motor

¹⁴⁰ David Nelson has shown that Taylor himself focused on developing the principles of his own methods in his own consulting work, often at the expense of problem solving. He didn't invent the assembly line or the incentive wage; rather he invented a way of studying the parameters and protocols related to these already existing systems.

¹⁴¹ Nelson provides the most thorough overview of the spaces of production where scientific management was developed and first installed by members of the Taylor Circle in Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915." He also provides an equally thorough overview of the dissemination to other disciplines and other countries in David Nelson, ed. *A Mental Revolution: Scientific Management since Taylor* (Columbus: Ohio State University Press, 1992). A more general overview of the reception of Taylor's ideas, is Judith Merkle, *Management and Ideology: The Legacy of the International Scientific Management* (University of California Press, 1980).

¹⁴² Frank and Lillian Gilbreth traveled through and lectured in Germany in late 1913, as part of a trip organized by the American Society of Mechanical Engineers. Through this trip they were introduced to the owners of *Auergesellschaft*, a German gas light company founded in 1892 and based in Berlin, named after its founder, the Austrian chemist Carl Auer von Welsbach (1858-1929). They had developed the OSRAM light bulb in 1901, and were closely affiliated with the AEG, leading some scholars to incorrectly claim that Gilbreth had consulted for that company. Gilbreth worked for Auer between January 8, 1914 to June 3, 1915, when the contract was cancelled, due to Auer's involvement in the war effort and Gilbreth's lack of a German passport. In May 1915, Gilbreth began consulting work for Carl Zeiss, the leading optical manufacturer and a cooperatively owned firm, in Jena, Germany, with that work also ending prematurely due the escalation of the Great War. Extensive documentation on this period is included in Gilbreth's archives, "Flga Box 133 Folder 0956." This period is briefly discussed in Brian Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940." (Purdue University, 1987). I will discuss Gilbreth's German work in more detail in Chapter 2.

Company, Du Pont, and the AEG, could afford to invest in costly experiments and to maintain and utilize careful data without hiring external consultants.¹⁴³

Despite a number of widely publicized mishaps surrounding the installation of standards attributable to Taylor in government owned facilities after 1910, such as at the Watertown Arsenal near Boston, and a subsequent ban on time study, entry into the Great War allowed Henry L. Gantt to install a more complete form of scientific management in the shipyards of the Emergency Fleet Corporation and at Frankford Arsenal between 1917 and 1918.¹⁴⁴ Four years later, Aleksei Gastev (1882-1939), a Russian poet and metal worker who had been exposed to Taylor's standard methods of metal cutting while working in France between 1910-1913, would, with the assistance of Frank Gilbreth, establish a laboratory of time and motion study at the Central Institute of Labor.¹⁴⁵ Although Gastev

¹⁴³ The AEG and Du Pont followed a similar pattern, assigning in-house mechanical engineers roles as industrial engineers, who in turn familiarized themselves with the literature regarding scientific management but also visited industrial plants where it was installed, such as Bethlehem Steel and Tabor. The AEG, became the exemplary case study of scientific management for other industries in Germany and elsewhere in Europe. A good example of this is Heinrich Nicklisch, *Wirtschaftliche Betriebslehre [Systematic Management Theory]*, 6 ed. (Stuttgart: C. E. Poeschel, 1922 (1912)). This highly influential publication tied Taylor's theories with AEG practice, publishing that firms extensive data, collected since 1898, when it sent one of its engineers on a study tour of America. For more on this see Rogge, "A Motor Must Look Like a Birthday Present." Du Pont was more secretive and less consistent with its dedication to the laboratory method, as discussed in John C. Rumm, "Scientific Management and Industrial Engineering at Dupont," in *A Mental Revolution: Scientific Management since Taylor*, ed. David Nelson (Columbus: Ohio State University Press, 1992). Nevertheless, the firm's industrial engineers eventually developed critical path planning, in 1956, displacing dominance of the gantt chart as the primary instrument of visualization. As I will show in Chapter 2, this instrument was itself rooted in the work of Gilbreth and Gantt.

¹⁴⁴ For more on Taylor's relationship and response to the Watertown Arsenal strike see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*. The Watertown Arsenal strike led to a ban on time study, one of the first forms of experimental standard derivation, in government run industrial facilities. Nevertheless, Henry Gantt was hired to consult for the Frankford Arsenal, near Philadelphia in 1917, and for the Emergency Fleet Corporation, a governmental entity that produced war ships, in 1918, with no reported strikes from the labor and much to the satisfaction of the US government. Gantt discussed his experiences in Henry L. Gantt, *Organizing for Work* (New York: Harcourt, Brace and Howe, 1919). His associates in this installations also discussed this work in Wallace Clark, *The Gantt Chart: A Working Tool of Management* (New York: The Ronald Press Company, 1922).

¹⁴⁵ Gastev was the founder and first director of the Central Institute of Labor from 1920 until his arrest in 1938. He was executed the following year. In 1920, Gastev wrote a letter for assistance from the American Relief Foundation, republished in the Bulletin of the Taylor Society in 1922. Frank Gilbreth maintained a correspondence with Gastev during this period. For more on Gastev see Bailes, "Alexei Gastev and the Soviet

praised the “experimental moment” of scientific management where “(s)cience is inserted into production practice” and “becomes an organic part of production”¹⁴⁶, the institute’s laboratories functioned more like typical material science labs, disconnected from the actual spaces of production. While proud to offer assistance to his Russian colleague, Frank Gilbreth showed much more enthusiasm for a government scale program in Germany, NADI.¹⁴⁷ Although Taylor himself had developed his principles exclusively within the context of private industrial plants, primarily machine shops, he had not hesitated in 1911, at the end of his career, to claim that “some principles” of scientific management could “be applied... to all social activities” including the “management of our homes”, “farms”, “businesses”, “churches”, “philanthropic institutions”, “universities” and “government departments”, without first prefacing with his own earlier caveat that the “application of the underlying principles must be modified to suit each particular case”.¹⁴⁸ Ironically, this late claim by Taylor regarding the applicability of scientific management to disciplines and contexts outside of the late capitalist American industrial plant have been used to credit and critique him and others rather uncritically. In this section, I have sought to more clearly

Controversy over Taylorism, 1918-24." A more extensive discussion of Gastev’s work within the context of interwar, as well as postwar, Soviet industry is included in Mark R. Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power* (London: Harvard University Press, 1988). I will discuss Gastev in more detail in the Conclusion.

¹⁴⁶ “Pri takikh potryasayushchikh kolichestvakh i skorostyakh proizvodstva moment eksperimentirovaniya, graficheskogo ucheta, analiza i izucheniya stanovitsya ne tem, chto nazyvayetsya «naukoy», vnosimoy v proizvodstvennyuyu «praktiku». Nauka stanovitsya organicheskom chast’yu proizvodstva.” Gastev, “Organizatsiya Proizvodstva Kak Nauka.” Republished in 1966 in *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda*.

¹⁴⁷ Unlike Gastev’s institute or the laboratories established in American universities and large corporations, the German program linked the space of the individual industrial plant with tentative standards proposed by individual enterprises, providing the unbiased review and further testing of these tentative standards in a space of normal production by a body of experts, specialists, as well as generalists, from numerous related industries, as a means by which to generate superstandards, known as DIN-Norms. These DIN-Norms were not obligatory, but were instead offered for use, allowing government institutions to select certain superstandards as the basis for required regulations. Subsequently, the sale of these DIN-Norms funded the independent agency, which was maintained by professionals rather than owners or bureaucrats.

¹⁴⁸ Taylor, *The Principles of Scientific Management*, 7-8.

define the central theory of scientific management, the laboratory method, as well as demonstrate the wide range of interpretations and explanations offered by Taylor, other members of the Taylor Circle, other disciplines, such as construction, and in other geographical and ideological contexts. A better understanding of what actually constituted scientific management has assisted scholars in developing a more nuanced critique of Taylor's own work; the same approach will now be used to assess the first discussions of the laboratory method, experimentation and standardization by European modernist architects.

Hermann Muthesius and the Theory of Evolving and Adapting Type, 1901-1920

Although Hermann Muthesius was not the first architect to discuss scientific management, with Peter Behrens, Le Corbusier and Martin Wagner having made reference to this mode of industrial organization two years earlier, his early texts and theories on the subject are notable for their comprehension, as well as for their capacity to inflect the further translation of scientific management, and particularly the laboratory idea into architectural design, and more specifically, settlement design practice. For these reasons, I will first discuss Muthesius' writings, from between 1918 and 1920, before turning to Peter Behrens, a fellow protagonist of the Werkbund, who Stanford Anderson has argued never fully grasped the creative potentials of the "tensions between norm and form", and Le Corbusier, who did.¹⁴⁹

¹⁴⁹ Martin Wagner briefly discussed Taylor and Gilbreth as early as 1918, but did not specifically discuss the laboratory method until much later, around 1924. On the other hand, he was the first to use standards directly attributable to Frank Gilbreth between 1918-19. He would also become the most active translator of scientific management literature, particularly Gilbreth's work in construction, during the interwar period, overseeing the dissemination of the actual tools of this approach through two journals he edited between 1921 and 1925. For this reason, I will discuss Wagner in more detail in Chapter 2.

As early as 1901, Hermann Muthesius defined his own theoretical project as the replacement of Academic composition, rooted in the formal study of historical styles, with a new mode of architectural work which would be based on the study of two models, that of vernacular building and that of industrial products and their spaces of production. Both models promised a renewed connection to “sources of *sachliche* progress”, which ubiquitous “architectural style-mongering” had “blocked”, therefore preventing architecture from evolving and adapting to new conditions.¹⁵⁰ While Muthesius acknowledged a general debt to the “ideas of Romanticism” and to the theories of men like John Ruskin and William Morris, whom he often cited, he chose instead to build his own theories singularly upon the practice of Norman Shaw.¹⁵¹ Within the highly influential *The English House*, Muthesius uses Shaw’s work as a model with which to present the later theories of “building with types” and “type building”. While Muthesius greatly admired Shaw’s “country houses”, it is in his discussion of Shaw’s “small houses”, that the seeds of his later theories can be detected. Muthesius would claim that Shaw consciously “broke with the styles of fine architecture, a step of the greatest importance in the history of art”,

¹⁵⁰ Hermann Muthesius, "Neues Ornament Unde Neue Kunst," *Dekorative Kunst* 4, no. 9 (June 1901). Translated and thoroughly discussed in Stanford Anderson, "Sachlichkeit and Modernity, or Realist Architecture," in *Otto Wagner: Reflections on the Raiment of Modernity* ed. Harry Mallgrave (1996). Here, Anderson redefined *sachlichkeit* not as “objectivity” but as “directness”, a definition that has since become more widely used by scholars. He also explained that the earlier theories of Ruskin and Morris were still respected at this time, but were seen as failures. Anderson indicates that at this time, Muthesius still found industrial products as the fruit of a more unconscious effort, like vernacular architecture, with the English domestic style being the only intentionally *sachlich* approach. I will show that this changed by 1913, the same year that *Principles* was translated into German. In 1901, the VDI began to discuss Taylor’s work in America. For more on this see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 525-27.

¹⁵¹ Muthesius always acknowledged the importance of the ideas of romanticism, despite his criticism of romantic architecture. Hermann Muthesius, *Style-Architecture and Building Art: Transformations of Architecture in the Nineteenth Century and Its Present Condition*, ed. Harry F. Malgrave, trans. Stanford Anderson, The Getty Center Publication Programs (Santa Monica: The Getty Center, 1994 (1902)), 62-63. Romanticism has an equally important role in *The English House, Volume I: Development*, trans. Janet Seligman (London: Frances Lincoln Ltd., 2007 (1904)).

¹⁵² both by studying contemporary middle-class life, new materials and methods, such as concrete construction, and most importantly by “having developed a new type of small house completely at home in England”.¹⁵³ The development of this type was not only deductive, the “means to this end was the *Villenkolonie* of Bedford Park”.¹⁵⁴ Foreshadowing his later theoretical argument, Muthesius claimed that Shaw had essentially “evolved a type” through an engagement in “building with types”, while the settlement, as a whole, functioned as his space of inquiry.¹⁵⁵ Writing in 1904, Muthesius claimed that the “experiment exceeded all expectations”, both in terms of refining the type, as well as in generating a new type of urban ensemble characterized by “a carefully calculated variety which yet managed to avoid the trivial and the picturesque, into which such attempts may easily degenerate”.¹⁵⁶ The project, which combined aesthetic quality with “economy”, also

¹⁵² *The English House, Volume I: Development*, 105. Muthesius’ own use of Shaw’s work as a model and his discussion of his critical assessment of disciplinary conventions is nearly identical to Stanford Anderson’s theory of “critical conventionalism”. Stanford Anderson, “Critical Conventionalism in Architecture,” *Assemblage*, no. 1 (October, 1986). Whether Shaw himself practiced this way or not, for Le Corbusier, Adolf Loos, Walter Gropius and many others, this was the first model modernist architect.

¹⁵³ Muthesius, *The English House, Volume I: Development*, 135.

¹⁵⁴ *Ibid.* For a more detailed history of Bedford Park see Walter Creese, *The Search for Environment: The Garden City, before and After* (Baltimore: The John Hopkins University Press, 1992 (1966)). Creese questions who was “responsible ... for its creation”, referring specifically to the “the new and revolutionary consciousness of space brought alive by light flickering through the trees.” For Muthesius, it was Shaw.

¹⁵⁵ In this text, Muthesius uses the German term *entwicklung*, or “evolution”, and *entwicklen*, or “evolve”, on a number of occasions to discuss the way that Shaw’s small house type was actively evolved through an iterative process. He would advocate the same process in his own manual on settlement design, *Kleinhaus und Kleinsiedlung* (1918), incorporating a discussion of scientific management into the second edition of this manual in 1920. In 1929, Ernst May would speak of “evolving 16 types” through his settlement-building work in Frankfurt. I will discuss his work in Chapter 5.

¹⁵⁶ Muthesius, *The English House, Volume I: Development*, 135. Walter Creese’s research supports Muthesius’ assessment of how the public responded to the spatial and temporal qualities of Bedford Park, but not as to what degree it was designed. Robert Stern, on the other hand is certain that “the plan (of Bedford Park) is not ‘composed’ in the way of F. L. Olmstead’s Riverside Scheme”, a conclusion that Muthesius wanted his readers to also reach. Stern’s conclusion that “Parker & Unwin’s Hampstead Garden Suburb” was also *composed* is not supported by Muthesius or Unwin’s own theories or Creese’s research, as I will show in Chapter 3, but it does explain how the ambitions for consciously deriving the unconscious character found at Bedford Park was never widely shared or appreciated. For Stern’s account see Robert Stern, *The Anglo American Suburb* (Architectural Design, 1981). Stern’s understanding of composition caused him to miss the significant differences between Hampstead Garden Suburb and Forest Hills Gardens, in his foreword to Peter Pennoyer

successfully disguised the fact that “only nine different types” were used, generating “the impression of an inexhaustible variety”.¹⁵⁷ While Muthesius’ characterization of this project was certainly at least in part operative, it would nevertheless serve as the primary example of engagement with type, which simultaneously led to its diachronic refinement and the production of a complex, synthetic, but not monotonous, set of relationships between essentially self-similar variants of a given type. Furthermore, it demonstrated the capacity for a project to be measured and experienced synchronically, in time and space, but also index the diachronic evolutionary activity in which the author was engaged. Whether Shaw himself had consciously intended to accomplish these goals is irrelevant, as it was Muthesius’ retroactive manifesto of this work, which would inform the activities of the subsequent generation, informing their own interpretation of scientific management. Taylor and Gilbreth offered architects more than new models of the “so-called beauty of the machine”, they offered the methods with which this beauty had supposedly been achieved.¹⁵⁸

and Anne Walker, *The Architecture of Grosvenor Atterbury* (New York: W W Norton & Co., 2009). I will also discuss this issue in Chapter 3.

¹⁵⁷ As Reyner Banham cynically pointed out, the possibility of unity and diversity, based on the example of the vernacular town, was an “argument to be repeated *ad nauseam* for the next forty years.” Reyner Banham, *Theory and Design in the First Machine Age* (Cambridge: The MIT Press, 1980 (1960)), 77. The argument was actually much older, as recent scholarship has shown; it was also as influential, if not more so, on the “new sense of space”, as the Futurist or Cubist sources that Banham preferred. For more on this see John MacArthur, *The Picturesque: Architecture, Disgust and Other Irregularities* (2007). The lack of understanding of typification, as the making of types, not the application of types, has also led to a number of misunderstandings. Here the 9 types are much closer in meaning to the tentative standard of scientific management than the ideal model of Academicism. Through their conception, construction and settlement in series, to paraphrase Le Corbusier, a more general type would eventually evolve.

¹⁵⁸ Mauro Guillen attempted to replace the machine aesthetic with the “organization aesthetic”. Guillen, *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture*. This is a logical conclusion from research that only focused on discourse, but it is through conjecture, drawing and the *translation of drawing to building* (to borrow a term from Robin Evans) that architects also experienced scientific management. The experience of standardization or experimentation generated an *aesthetic sensibility*, one that saw physical objects and spatial relationships as iterations of tentative standards.

By 1913, Muthesius discussed industry using a similar conceptual framework to the one he had based on Shaw's "experiment" at Bedford Park, explaining that the "history of human technology shows, step by step, that though the invention of new devices proceeds relatively fast and with apparent ease, men have always found it very hard to arrive at the definitive form for these new creations".¹⁵⁹ The process of arriving at that *definitive form* was what Muthesius would call *typisierung*, or "typification", a year later, and what the proponents of scientific management already called standardization.¹⁶⁰ In 1914, Walter Riezler, an archeologist and member of the Werkbund would lend his reading of the "evolution of the Greek temple" to Muthesius' vague call for "typification", in order to defend his colleague's call for a new direction for that organization.¹⁶¹ Seeking to

¹⁵⁹ Hermann Muthesius, "Das Formproblem Im Ingenieurbau," *Werkbund Jahrbuch* (1913). Republished in Julius Posener, *Anfänge Des Funktionalismus: Von Arts and Crafts Zum Deutschen Werkbund* (Berlin: Ulstein, 1964). This translation comes from Tim and Charlotte Benton, ed. *Form and Function : A Source Book for the History of Architecture and Design 1890-1939* (London: Crosby Lockwood Staples, 1975). That same year Frederick Winslow Taylor, *Die Grundsätze Wissenschaftlicher Betriebsführung* [The Principles of Scientific Management], trans. R. F. Rosler (Munich: R. Oldenburg, 1913). was published in Germany.

¹⁶⁰ In the English House, Muthesius used *entwicklung* for essentially the same process that he would call *Typisierung* as part of his famous speech at the Werkbund Congress in Cologne in 1914. The term was not widely used in architecture before that time, but it was common in literary criticism, where it denoted the way the pre-Romanticist literature treated individual characters as ideal types, as opposed to Romanticist literature where characters were shown to change and evolve; in other words, it was the complete opposite of Muthesius' intentions, giving linguistic basis to Henry Van de Velde's accusation that it constituted a return to Academicism, one of the few things that the Werkbund members could agree that they did not want. For more on the standard use of *Typisierung* before 1914, see Wolfgang Martini, "Victor Hugos Dramatische Technik Nach Ihrer Historischen Und Psychologischen Entwicklung, Teil I," *Zeitschrift für französische Sprache und Literatur* 27(1904). Nikolaus Pevsner officially equated "Typisierung" with "standardization" in Nikolaus Pevsner, *Pioneers of Modern Design: From William Morris to Walter Gropius* (London: Pelican, 1977 (1936)). Francesco Passanti and other contemporary scholars have emphasized the more culturalist implications of this term, translating it as typification, not standardization, which they see as too closely linked to industrial production.

¹⁶¹ Riezler's statements are included in Posener, *Anfänge Des Funktionalismus: Von Arts and Crafts Zum Deutschen Werkbund*, 215-16. Riezler alluded to the fact that the major discoveries of his field during the previous century, discoveries that had previously been presented as the work of "pure individualism" were in fact a combination of a more collective "gradual ... evolution", as well as individual creation. Neither Riezler nor Muthesius were questioning the value of the Classical Temple as an exemplary artifact, rather they were using what they saw as a more objective history of its formation, even the formation of a particular work, the Parthenon, as the foundation for a critique of Academicism as well as the lack of new conventions to replace it. Without citing this source, Anderson argues for exactly the same relationship between Le Corbusier and the Acropolis, in Anderson, "Critical Conventionalism in Architecture." Passanti follows Anderson's more theoretical argument with a specific discussion of Riezler in Passanti, "The Vernacular, Modernism, and Le

circumvent the binary between typification and individualism created by Henry Van de Velde and his supporters, who had equated typification with Academicism, Riezler turned to the Parthenon, explaining that it was at once the product of “the relentless work of centuries on a real practical problem” and the specific result of the “individual artistic sensibility” of Ictinus, its *building-artist*.¹⁶² While the Parthenon was therefore an individualistic work, he explained that recent developments in “the history of art” had shown that that work shared similar traits, both diachronically and synchronically, with numerous other temples, that it accepted all the basic characteristics of that type, and that the individual achievement itself was a result of the collective and accreted knowledge, as well as individual virtuosity. The Parthenon was therefore not only the result of the process of typification, which included the definition of a type and its evolution, but it was the foundation of the collective gradual work that supported the individual achievement. After Riezler’s comments, the *union of the most intimate enemies* erupted into accolades.¹⁶³ For Muthesius, the appearance and evolution of types was the real challenge, not only for the individual artist-architect, who he had ensured a place in industry production as the maker of prototypes for mass-reproduction, but for the discipline as whole, which was faced with an increasingly typified legislative context of copyrights and building regulations.¹⁶⁴

In 1917, exactly a decade after stabilizing the foundation of the Werkbund, Hermann Muthesius returned to the issue of settlement design through a speech in Berlin titled “Kleinhaus and Kleinsiedlung”, publishing an extensive settlement design manual carrying

Corbusier,” 449. He points to Riezler as the source of Le Corbusier’s treatment of the Parthenon in 1920. I will show that Muthesius uses the Parthenon for exactly the same purpose in the same year.

¹⁶² Posener, *Anfänge Des Funktionalismus: Von Arts and Crafts Zum Deutschen Werkbund*, 215.

¹⁶³ *Ibid.*, 216.

¹⁶⁴ If in 1914, the debates were primarily theoretical, following the 1917 formation of NADI and the increasing influence of engineers in the typification of the methods and measures of building, the need for architects to engage in typification activities became almost requisite.

the same title in late 1918.¹⁶⁵ Within this manual he would summarize and clarify his most important theories to date and in 1920, he would release a second expanded edition to include a detailed discussion both of scientific management and the NADI program, which had begun to shift its attention to the typification of building components. Just as Muthesius had argued for the architect's role in the creation of prototypes for mass production in 1907, he would now argue for a stake within the typification process. While the settlement design manual included chapters on every aspect of this particular area of architectural work, the main theoretical argument was inserted deep within the volume, in a chapter titled "Typenbau", and in the second edition a chapter titled *Wirtschaftliche Baubetriebsformen*, or "Systematically Managed Construction Methods", following right after.¹⁶⁶

Muthesius had spent much of the war considering the "real tumult" that his discussion of typification had caused at the Werkbund Exhibition in Cologne in 1914

¹⁶⁵ While this manual was highly influential in discussions around the so-called "settlement-question" during the early twenties, this manual disappeared, along with Muthesius, from the history of the modern movement. The only significant discussion I have found is included in Stalder, *Hermann Muthesius, 1861-1927: Das Landhaus Als Kulturgeschichtlicher Entwurf.*, 146-58. Stalder does discuss the chapter on *typenbau*, but not the chapter on scientific management. The first edition of the manual, published in 1918, included 37 chapters on every possible aspect of settlement-building, "Der Typenbau", the most theoretical chapter, being number 20. In the 1918 edition, Muthesius also cited Behrens' shorter treatise. The second, expanded edition, published in 1920, had the same number of chapters, with "Der Typenbau" significantly lengthened and paired with a shorter chapter on scientific management. This served as provisional conclusion, with the following few chapters speculating on the future "possibilities" for reforming settlement-building.

¹⁶⁶ German engineers and architects were more rigorous than their colleagues in other countries in distinguishing between systematic management, or *wirtschaftliche Betriebsführung*, and scientific management, or *wissenschaftliche Betriebsführung*. While the term *wirtschaft* does directly translate into economy, and denotes a particular space on a farmstead, the *platz*, or place, where productive work is done, this particular compound term means systematic management, and as such I will use this translation. As in America, systematic management is a broader term, with the earlier term Taylor-System, used in German engineer journals from around 1901, being a form of systematic management. Between the publication of *Principles* in German in 1913 and 1918, the two terms were used interchangeably, but by 1918, the two terms began to have distinct meanings, scientific management referring to the experimental derivation of standards while systematic management denoted a more planned form of management, but not the activities of derivation. Peter Behrens is the first German architect to actually use the term "scientific management", but Muthesius was the first to use both terms, "scientific" and "systematic management", correctly, in a single article.

among the “artists so in love with their *Ichnkunst*”, or “I-art”. As such, within the “Der Typenbau” chapter, Muthesius sought to dispel the assumptions that this proposal was a “threat to the sacred heritage of art”, an “experiment in limiting free creation” or a “regulation of artistic activity”, on par with Academicism.¹⁶⁷ Alternatively, he was wary of former critics who were now “singing like sparrows from the rooftops” about the need for “typicality”, producing a “buzzword” that might now go “too far in its demands”.¹⁶⁸ The negative, or at least confused, response to the term “typification” in 1914 led Muthesius to add a new term to his discourse; *Typenbau*. *Typenbau*, or “type building”, a term more familiar to architects and nearly synonymous with vernacular architecture, denoted the repetition and variation of a single type in a particular place and time. Like the related activities of the laboratory method, experimentation and standardization, type building, even more than the earlier term, typification, implied the conscious process of the synchronic individual application of a type, in order to participate in its collective evolution, through adaptation, diachronically. His frustration with his colleagues’ earlier inability to comprehend his ideas also led him to now introduce two new terms, at least in the context of his discussion of typification, that of the *technische Einheitsform*, or “technical unit form”, and of the *kunstlerische Einheitsform*, or “artistic unit form”, or better translated, “the artistic unity of form”, two concepts “between whom contacts do take place” but which in terms of “intention and goal are separate”.¹⁶⁹

¹⁶⁷ “eine Bedrohung der heiligsten Güter der Kunst“, “den Versuch einer Knebelung des freien Schaffens“, “Reglementierung der künstlerischen Schöpferkraft“ Muthesius, “Der Typenbau (Type Building),” 317. No change from the first edition.

¹⁶⁸ He used the word “Typischen”, not “Typisierung”, here. Ibid.

¹⁶⁹ Ibid., 315. While not significantly different from the earlier edition, Muthesius’ edited a number of minor features of this discussion. Laurent Stalder has accurately pointed to the roots of these theories in the work of Gottfried Semper and Alois Riegl, Stalder, *Hermann Muthesius, 1861-1927: Das Landhaus Als Kulturgeschichtlicher Entwurf.*, 81.

The “technical unit form” arose from “usefulness”, as is “created because it is advantageous to manufacture, use and price”, and which can be found in “all products of craft and enterprise”, such as in “our clothing, our tools, our devices, our machines”, as well as in the “interchangeable components of engineering construction”, and “building construction”.¹⁷⁰ These unit forms, partially typified, continued to evolve through a process of “progressive improvement” through their application in manufacturing and daily use, as mass consumer products.¹⁷¹ Muthesius points to the usefulness of “building with types”, both in manual labor and “even more so in machine production”, allowing “a variety of consumers”, working in “different places”, to build more cheaply but to also increase their own individual “familiarity” and skill in the use of these “unit-forms”.¹⁷² In turn, these “consumers”, through their individual and increasingly skilled use of these “unit forms”, contribute to and benefit from these “unit forms” since they “reflect the work of whole generations”.¹⁷³ Furthermore, Muthesius concludes that it is this “continuous improvement of the type that has made the tremendous technical refinements possible to which we owe our current machine tools, the airplane and the scientific instrument” as it could be assumed that the same “flawless results would be difficult to achieve” if one began from

¹⁷⁰ Muthesius, "Der Typenbau (Type Building)," 315. Muthesius carefully distinguished what was already in practice in *Ingenieurkonstruktion*, or “engineering construction”, and *Bauausführung*, “contracting work” or more conventional construction, in Germany. The transfer of conventions between these two spheres was not to be taken for granted. Eight years later, Sigfried Giedion would anoint Le Corbusier architecture’s Prometheus, bringing engineering construction into architectural practice. In fact, Le Corbusier had attempted a slightly different feat, bringing systems he believed were already in use in American contracting work, for workers housing, to France.

¹⁷¹ In Gilbreth’s terms, they are tentative standards adapting and evolving towards superstandards.

¹⁷² Muthesius, "Der Typenbau (Type Building)," 315. Here, Muthesius is discussing what Wilhelm Lübbert, the head of the “experimental settlement” program, would later call the “rationalization of mental work”, through better information technology tools. I will discuss Lübbert in detail in Chapter 5.

¹⁷³ *Ibid.*, 316. The language is essentially the same as the 1914 discussion of the evolution of the Greek Temple.

scratch, with an entirely “new experiment having all of the inherent flaws of amateur work.”¹⁷⁴ *Building with types* was the essential method for *building* or *evolving types*.

Muthesius distinguished the “artistic unit-form” and “unity of form”, from that of the “technical unit-form”, as they did not “arise from the pursuit of usefulness”, but their development alluded to similar evolutionary logics.¹⁷⁵ He provided three examples of “building types” that constituted “artistic unit-forms” from their particular “ages”, the “Greek Temple of Antiquity”, the “Cathedral of the Middle Ages” and the “Princely Palace of the 18th century”, as well as examples from the “the arts”, such as the “Madonna and Child of the Renaissance”, found in painting and sculpture.¹⁷⁶ Alternatively, the 19th century was derided for its “mistaken starting point” of “alternately repeating the formal languages of the past”, instead of engaging in “the common pursuit, adherence and development of contemporary types”¹⁷⁷; for Muthesius, types were certainly not timeless nor the direct reflections of an age, but rather the collective efforts of numerous individuals. In addition to the “repetition of formal languages of the past” put forth by eclectic academicism historicism, he was also critical of the “personal art” of the Secession, “evolved from the inner worlds of the artist for his personal use” and “lacking any factual basis”.¹⁷⁸ That

¹⁷⁴ “Ein tadelloses Ergebnis ist schwer zu erreichen, wenn grundverschiedene Dinge hergestellt werden, von denen jedes gewissermaßen einen neuen Versuch mit allen einer Anfängerarbeit anhaftenden Mängeln bedeutet. Nur auf der fortlaufenden Vervollkommnung des Typ's sind jene ungeheure technischen Verfeinerungen möglich gewesen, denen wir beispielsweise die heutige Arbeitsmaschine, das Flugzeug, das wissenschaftliche Instrument verdanken.” Ibid. Here, the choice of more innovative technological objects emphasized the ontological issues at hand. Experimentation cannot simply be an attempt, a “new experiment”, but rather it needs a foundation from which to evolve.

¹⁷⁵ Ibid., 316-17. Here the unit and unity are used interchangeably; Alois Riegl, not Gottfried Semper, is the primary source.

¹⁷⁶ Ibid., 316.

¹⁷⁷ Ibid.

¹⁷⁸ Ibid. Academicism stifled personal “entwicklung” as much as a lack of engagement with “facts” and “preconditions”. In his earlier texts, Muthesius found historical eclecticism tolerable because it offered the modern architect a variety of expressive languages with which to handle different programs. Stanford

“factual basis” lay outside of the central disciplinary concerns of form and composition and instead in the “technical unit forms” of new materials and social organizations. Here, Muthesius repeated Riezler’s earlier arguments, stating that, while distinct from “technical unit forms”, the “artistic unit form is also achieved through the work of many individuals, even of entire generations focusing on the same object, a perfection, a performance, a refinement, not conceivable through the work of any one individual,” which could be seen “carried out ... to the utmost ... in the Greek temples.”¹⁷⁹ The German architect would go further than his archeologist friend, showing the link between the evolution of a technical unit form and that of perceptual, formal development, in a component of the temple, the “long horizontal beam” intentionally curved so as to appear straight to the eye. This “optical illusion” was not achieved “mathematically” but was instead the result of a process of trial and error, of construction, perception and reflection, lasting many generations, with this formal technique following a development process similar to the technical unit form, despite not being specifically driven by functionality. Muthesius explained the evolution of aesthetic sensibility through a similar process, with “connoisseurship raised” and the “power of discrimination” perfected by studying differing variants of the same type.¹⁸⁰

Anderson has shown the persistence of this approach in Peter Behrens’ factory projects for the AEG. Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*.

¹⁷⁹ Muthesius, “Der Typenbau (Type Building),” 317. Muthesius had not devoted this much discussion to Hellenic architecture in his previous major publications, although he shared the view of architects steeped in Romanticist theory that Greek architecture shared many of the same qualities of Gothic architecture. Whether this particular application of typological theory to the Temple, already included in the 1918 edition of the manual, was known to Le Corbusier before he wrote his 1920 text, on the same subject, is not clear, but as Passanti and other scholars have shown, Muthesius’ general influence is clear there.

¹⁸⁰ “Die Beobachtung, daß eine lange wagerechte Linie, wie das Gebälk über einer Säulenhalle, dem Auge in der Mitte eingesenkt erscheint, hat dazu veranlaßt, die sogenannte Krümmung, d. h. eine leichte Aufwärtsbiegung der wagerechten Linien, einzuführen, um der Augentäuschung entgegenzuarbeiten. Dasselbe ist bei der bekannten Schwellung der antiken Säule der Fall: eine mathematisch walzenförmige Trommel würde, mager und dürrig, erscheinen; die kunstliche Ausbiegung des Umrisses verleiht ihr für das Sehempfinden des Menschen die Vollkommenheit.” Ibid. Here, Muthesius is clearly emphasizing the fact that he is not only talking about technical or social evolution and adaptation, he is also

With the more unconventional meaning of Typenbau, as the “evolving of types”, explained, Muthesius now turned to the more common meaning of Typenbau, “building with types”, through a discussion of the “unit form in natural formations”, hoping to clarify the “true meaning of artistic formal unity”. He repeated his opening argument that despite sharing common characteristics and belonging to a general category, it was difficult to “find two oak leaves (whose form) coincides completely”, and that there is such a “diversity” in the relationship of “eye, nose, mouth and ears” in a given face that even “confusing two (faces) among the thousands of millions of people” for one another is “very rare”.¹⁸¹ Furthermore, Muthesius contended it was the very existence of a partial similarity of unit forms to one another that garnered an “emotional response” in the viewer when noticing the nuanced differences in each instance. In addition to the internal relationships of one variant of a unit form to another, Muthesius also discussed a second relational aesthetic,

discussing the very nature of visual form, as a collective language developed through time, not as an essential set of truths or a set of disciplinary conventions. Here his own reading comes closer to the postwar linguistic theories of serialism, generally ignored by architects in favor of structuralist linguistics, with its promise of more defined links between perceived form and syntactical structures. Henri Lefebvre critiqued structuralist and poststructuralist linguistics for “completely ignor(ing) the yawning gap that separates this linguistic mental space from that social space wherein language becomes practice.” Henri Lefebvre, *The Production of Space*, trans. Donald Nicholson-Smith (Oxford: Blackwell, 1991 (1974)), 5. Umberto Eco explained that “(t)he main goal of serial thought is to allow codes to evolve historically and to discover new ones, rather than to trace them back to the original generative Code (the Structure). Thus serial thought aims at the production of history and not the rediscovery, beneath history, of the atemporal abscissa-e of all possible communication. In other words, the aim of structural thought is to discover, whereas that of serial thought is to produce.” Umberto Eco, *The Open Work: The Poetics of Indeterminacy* (Cambridge: Harvard University Press, 1989 (1962)), 221.

¹⁸¹ Muthesius, “Der Typenbau (Type Building),” 318. In this later text, Muthesius is clearly trying to expand his theoretical breadth from the culturalist realm and his vernacular and mass consumer models to the models of Academicism, Classical architecture and nature. This more Academicist view of the vernacular model was more common to Heinrich Tessenow. For a discussion of Academicism and type, see Stanford Anderson, “Types and Conventions in Time: Toward a History for the Duration and Change of Artifacts,” *Perspecta* 18(1982). For Anderson, Semper constitutes a shift towards the more relativist, adaptive and culturalist point of view of type, embodied in vernacular architecture, shared by Muthesius. It is worth comparing the discussion of the human face to a third interpretation of the vernacular model in Germany, that of the more politically and aesthetically conservative architects like Paul Schultze-Naumburg and Paul Schmitthenner, who would use the Aryan face and German vernacular to support a very different world view. For more on an example of this use of the vernacular see, Paul Schmitthenner, “Tradition and New ” *Deutsche Kulturwacht* 17(1933).

that of distinct variants of a unit form to its immediate context, pointing to the differences visible in the “lower leaves of a plant” impacted by “better sunlight”, “exposure to wind”, or the adverse affects of neighboring leaves.¹⁸² In relation to buildings, he pointed to the influence of “special factors” whose impact distinguished each “individual building” from a general “type”, with those factors being the “building material used, the economic conditions of the place where it was built”, as well as the influence of “other buildings or natural structures” in the vicinity.¹⁸³ It was in the dialogue of *type* and *change* that a “sense of individuality” was generated. While “older buildings were the result of a time when it was quite common to work from given unit-forms”, Muthesius lamented that “our contemporary streets” are the result of “indiscriminate and deliberate deviations”, the product of “every architect puffing up to draw attention to his own design” and resulting in a “visual noise which even exceeds the acoustical noise of street traffic.”¹⁸⁴

Significant differences between the 1918 and 1920 edition of the *Kleinhaus und Kleinsiedlung* manual, which introduced NADI and scientific management, began with the discussion of “the technical unit-form applied to the small house”. Again, the difference between “technical unit form” and “artistic unit (and unity) of form” were repeated, with the former receiving significantly more discussion than the latter. Here, Muthesius would introduce an important distinction that would be repeated for the better part of the next half-century, namely that while the application of “technical unit forms”, both in terms of

¹⁸² Muthesius, "Der Typenbau (Type Building)," 319. John Ruskin encouraged the study of botany and geology to his drawing pupils for the same reasons, hoping that these conventions would replace those developed after Rafael. For more on these principles see John Ruskin, *The Elements of Drawing: In Three Letters to Beginners* (New York: Wiley & Halstead, 1858). These principles were still common in artistic education when many modernist architects, including Le Corbusier and Ernst May were young.

¹⁸³ Muthesius, "Der Typenbau (Type Building)," 319. The disappearance of these tectonic, social and formal preconditions led modernist architects to embrace those that still remained, such as solar orientation and wind direction.

¹⁸⁴ Ibid.

building components and construction methods, would be “advantageous”, “economical” and “systematic” or “efficient”, and in fact were already common, the application of this approach to the “overall form” of the “whole house” raised a number of problems and should therefore be approached more cautiously, with the caution only increasing from the first to the second edition.¹⁸⁵ A “normal format” brick already existed, leading to a standard module of wall thicknesses, and Muthesius believed that other building components, such as roof tiles, façade tiles, stove tiles, linoleum and wallpaper widths, window and door frames, as well as lumber would be standardized, just as steel sections had been a decade earlier.¹⁸⁶

Muthesius then turned to windows and doors, “whose suitability to having a predefined unit form had been recognized for some time”.¹⁸⁷ He began with a discussion of his first major *kleinsiedlung* project, *Gartenstadt Hellerau* near Dresden (1909-1911), where he had been left with considerable leeway to develop his own district of the larger settlement, as well as to define a “limited number and fixed dimension of windows and doors”, which all of the participating architects used, voluntarily.¹⁸⁸ (Fig. 03) By the second edition, the discussion of the *Typisierungsarbeit*, or “typification work”, at Hellerau, was shortened, with Muthesius describing the project as primarily of “historical value today” in

¹⁸⁵ Ibid., 319-20.

¹⁸⁶ Ibid., 320. The standard wall module, used for planning, ranged from 12, to 25, to 38, to 51 cm in depth, all multiples of a standard brick, with tolerance for mortar.

¹⁸⁷ Ibid. Muthesius was discussing them in the context of his own work, and in the second edition, that of NADI.

¹⁸⁸ Richard Riemerschmid was responsible for the overall settlement design at Hellerau. The fixed dimension windows and doors were used by all of the architects with the exception of Heinrich Tessenow. These building components, which had themselves been produced nearby, in the *Werkbund-Werkstatt*.

comparison to the work being carried out by NADI.¹⁸⁹ While the scale of typification had shifted, much to Muthesius' pleasant surprise, the basic principles were still the same. Types, or industrial norms, still evolved locally, before being collected by the non-governmental association, analyzed by interdisciplinary expert teams and offered back to individual practitioners, for voluntary use. Muthesius included a recent history of the association, focusing his analysis on the work of one of NADI's newly formed subcommittee's, the *Reichshochbaunormung*, who had published their first DIN-Norms specifically for *kleinhausbau* in October 1919.¹⁹⁰ (Fig. 03) Muthesius emphasized the fact that these new standards reflected the specific experiences of various industries, including brick manufacturers, "representatives of the glass industry", as well as architects, synthesizing numerous tentative standards into superstandards, offered but not enforced by this non-profit organization.¹⁹¹ He tempered this enthusiasm with caution, pointing out the fact that the particular dimensions, as well as the performance of the *Reichnormfenster*, suggested "specific artistic effects ... not desirable in every building" and not appropriate to the climactic and cultural conditions of some regions of Germany. Far from treating these standards as purely objective, he pointed to aesthetic "biases", which he attributed to the contemporary "efforts in small-house building to emulate the historic small farm house", as well as the somewhat disproportionate influence of the window manufacturer in "reducing the variety of dimensions ... in the window frame" who sought "savings" by limiting the

¹⁸⁹ Muthesius made no claims as to directly influencing NADI, but he clearly found it's founding a validation of his earlier forecast about the future. He had been following VDI's work since they first standardized steel sections, in 1901, following Taylor's basic principles.

¹⁹⁰ Muthesius, "Der Typenbau (Type Building)," 321. This discussion was not included in the first edition. Gilbreth owned the same DIN-Norms. "Flga Box 129 Folder 0926."

¹⁹¹ "Der Typenbau (Type Building)," 324. Gilbreth made very similar points two years later, Gilbreth, "Superstandards: Their Derivation, Significance and Value." Peter Behrens discussed the formation of this subcommittee as well in Behrens, "Die Gruppenbauweise." As with scientific management itself, the discussion was earlier but less comprehensive or insightful.

types of equipment he needed to purchase.¹⁹² Despite these criticisms, if the process of typification remained open ended and if the architect was included in the process, Muthesius thought this to be a positive development, a conscious and accelerated version of the same, more *unconscious*, evolution and adaptation he and others had admired in vernacular architecture and industry, before 1913. With German industry corroborating his earlier call for architects to not only provide prototypes but to also engage in typification, Muthesius again turned to the future of architecture, as he had in 1914.

While Muthesius saw the “typification of individual building components” as inevitable and generally positive, he felt that the same approach could not be applied “to the same degree” to the “building as a whole”.¹⁹³ A “clear direction towards unification” had already emerged in “prewar workers and clerks housing”, as exemplified by the “elongated rectangular floor plan type”, consisting of two rooms, divided by a stair, and connected to a kitchen garden in the back.¹⁹⁴ Like the farmhouse window that was the source of the first DIN-Norms, this plan still reflected the earlier model of the “old farmhouse”, and the “unification” of house and garden could “scarcely be noted”. Muthesius predicted that it

¹⁹² Muthesius, “Der Typenbau (Type Building),” 324. The critique of a single vernacular type becoming a kind of fashion is likely a veiled critique of Heinrich Tessenow. His influence would persist along side Muthesius’ in the later RFG program, through his own participation and the work of his former student, Alexander Klein. Klein’s use of the universalized small farm house type as a model for his own work for the RFG is clearly visible in his chapter, Alexander Klein, “Beitrage Zur Wohnungsfrage,” in *Probleme Des Bauens*, ed. Fritz Block (Potsdam: Müller & Kiepenheuer, January 1928).

¹⁹³ “Zum Unterschiede von der Typisierung der Einzelteile des Baues wird sich die überführung des ganzen Hauses auf eine Grundform vorläufig nicht in dem von Vielen gewünschten Grade durchführen lassen.” In this text, unchanged from the 1918 edition, the term Typisierung finally reappears. Muthesius, “Der Typenbau (Type Building),” 325. Walter Gropius would briefly advocate the typification of entire buildings, before he himself engaged in the process, at which point he essentially repeated Muthesius’ argument. I will discuss this in more detail in Chapter 5.

¹⁹⁴ Ibid. In an earlier section of the manual, Muthesius discussed the small house and the allotment garden, including a number of schemes designed by Leberecht Migge (1881-1935), the landscape architect that would work on nearly every major siedlung in Germany during the Weimar period. He was skeptical of Migge’s promise of economical self-sufficiency but was otherwise positive about his work. *Kleinhaus Und Kleinsiedlung*, 2nd ed. (Munich: F. Bruckmann, 1920), 165. Although he didn’t point it out, Muthesius had described many of Migge’s principles before the young designer even started his professional apprenticeship, in 1904 in *The English House, Volume I: Development*.

“would be the task of the next decade” to “evolve” a “new house” from this “initial base point.”¹⁹⁵

In this endeavor, he encouraged his colleagues to keep the “locational and temporal contingency of types” in mind.¹⁹⁶ Historically “house types had evolved distinctly in different places,” so it was “therefore wrong to now want to establish universally valid elementary forms” and “it would be impossible to maintain those forms definitively over a longer period of time”.¹⁹⁷ Rephrased again in different terms, “the locational and temporal limits of a type had always constituted its most important precondition, its further evolution should never be obstructed through over-regulation”.¹⁹⁸ If architects were not careful, the “typification of the small house could result in a rigid (evolutionary) condition” and the “inefficient layout” of the Berlin *Mietskaserne*.¹⁹⁹ Nevertheless, a new “type building”, or “typification”, approach, which could gradually lead to the “improvement of the house as a whole” was needed. A “spiritualization of the nature of the small house” analogous to the one guiding the “improvement exhibited in our machines, weapons and aircraft which has resulted from advancements in the methods of manufacture”, was

¹⁹⁵ “Die Entwicklung für dieses sich zwar an das frühere kleine Bauernhaus anschließende, aber doch in vieler Beziehung neuartige Haus ist soeben erst angetreten. Es wird Aufgabe des nächsten Jahrzehnts sein, feste Grundlinien für seine Anlage zu gewinnen.” “Der Typenbau (Type Building),” 326. This “evolution” of the small house and allotment garden would be the primary detailed design issue of settlement-building.

¹⁹⁶ “Örtliche und zeitliche Bedingtheit der Typen” *ibid.*

¹⁹⁷ “Im übrigen ist die Tatsache hervorzuheben, daß die Entwicklung der Haustypen in verschiedenen Gegenden immer verschieden ist. Es wäre daher verfehlt, allgemein gültige Grundformen aufstellen zu wollen, ebenso wie es unmöglich ist, die etwa gewählten Grundformen für längere Zeiträume festzulegen.” While the spirit of this statement is prevalent in most of Muthesius’ writings, he had never been this clear and concise before. It was unchanged from the 1918 edition. *Ibid.*

¹⁹⁸ “Die örtliche und zeitliche Beschränktheit der Typen ist überhaupt stets Voraussetzung, niemals darf durch Reglementierung die fernere Entwicklung unterbunden werden.” *Ibid.*, 327.

¹⁹⁹ *Ibid.* The *Mietskaserne* would be used throughout this period as a model of regulation gone wrong. A similar argument was repeated by the director of the “experimental settlements” program, Wilhelm Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]* (Berlin: Arbeitsgemeinschaft für Rationalisierung im Bauwesen/Beuth Verlag 1926). Muthesius also included plans prepared by the *Groß-Berliner Verein für Kleinwohnungswesen*, where Martin Wagner worked during the war; he neither critiqued nor praised them.

essential.²⁰⁰ The scientific study of earlier methods of manufacture provided a model for a new approach, the “scientific analysis of construction”, where “irrational ... firmly rooted habits” could be rectified. Instead of rationalistically or intuitively deducing new types, Muthesius hoped that architects would use these new methods to analyze “what has already been erected” in order to “meaningfully define floor plan types and to assist in all typification and *Normung* (norming or standardization) activities in general”.²⁰¹

In considering the necessary “limits of typification”, Muthesius argued that architects should be mindful of the “effects of standardization on various constituencies”, including their own colleagues, who would have to work with these standards, such as “trained artisans, representatives of industry and commerce, representatives of professional organizations and associations, as well as other specialists.”²⁰² For architects, the greatest potential benefit would occur in terms of projection, both in the “preparation of drawing sets and in the estimation of costs.”²⁰³ However, the “effort of mass calculation” of a given standard should not ignore or be overburdened with contingencies to such an

²⁰⁰ “Es wird bei durchdringender Beschäftigung mit dem Gegenstand auch hier eine Durchgeistigung des ganzen Wesens des Kleinhauses eintreten, *gleich der Vervollkommnung, die unsere Maschinen, Waffen und Flugzeuge durch fortgesetzt verbesserte Herstellungsarten erfahren.*” Muthesius, “Der Typenbau (Type Building),” 327. I have italicized the second half of the sentence to indicate that it was added in 1920. Therefore “spiritualization” of the small house was already included in the 1918 text, while a more detailed discussion of the “methods of manufacture” was added in 1920, to better transition into the next chapter on scientific management. Architecture, following the “modern spirit” of *Taylorisme*, was also the subject of a series of texts written by Le Corbusier between 1918 and 1922, which I will discuss here and in Chapter 4.

²⁰¹ “Jede Festlegung von Grundrißtypen und jede Normung und Typisierung überhaupt kann daher nur immer die eine Bedeutung haben, das bisher Erreichte zu verzeichnen.” Ibid.

²⁰² Ibid. Muthesius would also consider what scientific management would mean for Germany’s cooperatively owned construction companies.

²⁰³ Ibid., 328. Here Muthesius substantiates Robin Evans’ argument that architects primarily produce drawings, and that others in turn use these drawings in a myriad of ways. Robin Evans, “Architectural Projection,” in *Architecture and Its Image: Four Centuries of Architectural Representations*, ed. Eve Blau and Edward Kaufman (Montreal: Canadian Centre for Architecture, 1989). The “experimental settlement” program referred to the application of scientific management to this form of *architectural mass production* as the “rationalization of mental work”, not only for the architect, but also for a host of other professionals. Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]*. I will discuss this extensively in Chapter 5.

extent that it rendered the standard useless; in this regard, Muthesius advocated that the architect should consider the use of the particular standard in daily life.²⁰⁴ In general, he saw greater benefits in the organization of the architect's work and of the dwelling itself, areas where more rigid typification had existed for some time within "construction", where it would "play a lesser role ... due to the fact that the construction of housing was still, to this day, manual," as the "transfer of factory mass-production, which today dominates nearly all other production, had not yet occurred."²⁰⁵ For the time being, Muthesius advocated an approach more similar to the "basic modules" used in the Japanese home, which are "always a multiple of the length and width of a floor mat".²⁰⁶ He understood the difference between industrial organization and mechanization. Until such a time when "whole houses c[ould] be cast at once in concrete", as proposed by Edison, the "preconditions demanding the standardization of the whole house" did not exist.²⁰⁷

²⁰⁴ Here Muthesius is considering the nature of "rationalization", as Max Weber would define it during this period, in relation to bureaucracy. James Beniger has defined two poles of Weber's theory of rationalization, on the one end the increase of "capability to process information" and on the other a decrease in "the amount of information to be processed". James Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, MA: The Harvard University Press, 1986), 15. For Muthesius, there is a third option, which relies on a network of professionals, working in tandem and applying a type, such as a "small house plan", to particular conditions, in order to both respond specifically to those conditions, as well as to produce more general disciplinary knowledge, which would eventually result in the revision of the type.

²⁰⁵ Muthesius, "Der Typenbau (Type Building)," 327. This statement is a good reflection of what Passanti calls the *vernacular as conceptual model*. While certainly not ambivalent about how mass production techniques will be transferred from the factory and engineering construction to "small house building", Muthesius is also not advocating for it as a solution to a particular architectural problem, but as a future "precondition" to which architects will have to respond.

²⁰⁶ Ibid. Muthesius lived and worked in Japan during the early 1890s. The Japanese module was a dimensional norm, i.e. it had real numerical controls, not only proportions, but it reflected a long period of evolution and inputs from various constituencies. A very similar approach is visible in Le Corbusier's use of the largest producible window frame, as the basis for his settlement system, after 1924, or Ernst May's modular system for his prefabricated concrete panels, first developed in 1926.

²⁰⁷ Ibid.. Although Muthesius probably did not know it at the time, Edison's deductive conclusion that houses could and should be poured in one motion, with the aid of a single mold, proved deeply flawed, as I will show in detail in chapter 3. The system's failure proved many of Muthesius' theories of typification, just as the system's evolution, into a more viable construction technique, by two American engineers working in Holland and France, followed the laboratory method and used Frank Gilbreth's techniques of motion study.

In response to the fact that the “so-called scientific management” had “generated so much discussion”, Muthesius devoted the subsequent chapter to the topic, framed theoretically by his notion of *Typenbau*.²⁰⁸ Just as Taylor had done in “Shop Management”, Muthesius carefully distinguished the “scientific study of construction” from the “systematically managed construction plant”, the chapter title.²⁰⁹ The German architect shared Frank Gilbreth’s admiration for vernacular building traditions along with his sense of the “backwardness of the construction business”, explaining that “in order to save small-house-building”, the “medieval state of our German construction plants ... could no longer be ignored.”²¹⁰ Being that the majority of employees working in German construction were “artisans”, improvements would need to be limited to “the transportation of materials to the site, the installation of scaffolding and the conveying of bricks and mortar” through the site, all references to techniques developed by Frank Gilbreth a decade earlier.²¹¹ These techniques had coincided with the introduction of the “crane, which had been widely in use for decades ... especially in England and America”, but was still rare in residential

²⁰⁸ "Wirtschaftliche Baubetriebsformen (Systematically Managed Building Methods)." As far as I know, this important text of scientific management by the founder of the Werkbund has never been analyzed. The chapter was actually only two pages, and could have been included as a section of “Der Typenbau”, of which it was an extension. Typenbau, building with types, was equated to “scientific management”.

²⁰⁹ As I have already discussed, Muthesius was careful to distinguish between “scientific” development of methods and a “systematic”, but not scientific approach to management.

²¹⁰ Muthesius, "Wirtschaftliche Baubetriebsformen (Systematically Managed Building Methods)," 332. An admiration of vernacular craft and skill is even discernible in Taylor and certainly explicit in the writings and work of Frank Gilbreth, as I will show in Chapter 2. Muthesius’ emphasis here is on the construction plant itself, not the skill of the German ‘artisan’.

²¹¹ Ibid. Here, Muthesius shows familiarity not only with Taylor’s discussion of Gilbreth in Principles, published in German in 1913, but also of material from an earlier publication of Gilbreth’s, *Bricklaying System* (1909), which I will discuss in more detail in Chapter 2. Whereas Taylor primarily emphasized Gilbreth’s work on bricklaying as an application of his principles and as the development of more precise numerical parameters for planning and management of work, Gilbreth had discussed how his techniques are used to assist skilled artisans in their work.

construction in Germany²¹²; the introduction of these methods and tools would present new challenges for the German architect.

These “American improvements” went beyond labor saving devices to include “studies of working methods”, as well as the “scientific analysis of construction”, first developed “by Taylor, who worked for twenty years ... in various types of industries and companies”.²¹³ Taylor’s “scientific method” was not only applied to the “simplification and improvement of particular tasks” but was also significant to the restructuring of “overall management”, and provided a “possible direction for the evolution of the systemization of building”.²¹⁴ Muthesius then singled out Frank Gilbreth, distinguishing his application of scientific management to construction from Taylor’s more general theories and methods. “Worker’s resistance” to scientific management, as well as the need for a “complete conversion of the ruling circles to this mode of thought”, needed to be considered before one could “imagine implementing a truly scientific management”.²¹⁵ Muthesius speculated that the recently formed “cooperative construction companies” might be ideal candidates for translating these “American improvements”, where the “surplus generated” by increased efficiency might be “equally distributed by the end of the year to all of the (cooperative) members”.²¹⁶ He concluded that Germany’s “troubled times” may in fact

²¹² Ibid., 333. The crane, like the scaffold were instruments around which Gilbreth had developed his motion study techniques, before engaging the smaller individual work stations of the factory.

²¹³ Ibid.

²¹⁴ Ibid.

²¹⁵ Ibid. Highly publicized strikes in America and France reached German workers by 1914, when Gilbreth began consulting there. At Carl Zeiss, he responded to their fears regarding “Taylorism” by demonstrating his own skill as a craftsman. Price, “One Best Way: Frank and Lillian Gilbreth’s Transformation of Scientific Management, 1885-1940,” 270. Muthesius’ experience with lobbying for a greater role for the architect in product design among “ruling circles” a decade earlier probably influenced his thinking here.

²¹⁶ Martin Wagner would pick up this charge, advocating for scientific management and disseminating Gilbreth’s techniques among the Bauhutte movement, between 1921 and 1925. I will discuss this in more detail in Chapter 2. For a general overview of political economy of housing delivery in Germany at this time

“offer an opportunity to introduce changes that would not be possible during a happier time”.²¹⁷

While Muthesius was certainly not the first architect to discuss scientific management, he was certainly the most thorough. His earlier theories, based upon the observation of industries that in fact had adopted scientific management, such as the AEG, were highly compatible with scientific management discourse, particularly that of the “laboratory method”. The two earlier published discussions by Peter Behrens and Le Corbusier, as well as later texts by Martin Wagner, Walter Gropius, Ernst May and Wilhelm Lübbert on scientific management were all influenced by the discourse of the Werkbund founder. The first of these texts on scientific management was published as part of Peter Behrens and Heinrich de Fries’ settlement design treatise, *Toward Economical Building: A Contribution to the Settlement Question*, published in March 1918, and cited in the first edition of Muthesius’ more extensive settlement design manual later that same year. While I will discuss Behrens’ work associated with this treatise in a subsequent chapter, it is worthwhile to examine the material specifically related to scientific management as part of this discussion.

Peter Behrens and Scientific Management, 1918

In his 1918 treatise, within a chapter titled “savings through technical construction”, Behrens included a section titled the “scientific management in the building trades”.²¹⁸ Like

see Barbara Miller Lane, *Architecture and Politics in Germany, 1918-1945* (Cambridge: Harvard University Press, 1968).

²¹⁷ The highly unstable German economy during this period did open opportunities for experimentation but also created nearly impossible preconditions for economical efficiency, particularly since every mark spent building housing meant another mark spent paying for credit; by early 1929, hyper inflation had doubled construction costs from 1914. Ernst May, "Grundlagen Der Frankfurter Wohnungsbau-Politik," *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 7/8(July-August 1928).

Muthesius, Behrens pointed to the “organizational approaches” being used in industrial production, as well as in “industrialized construction”, to erect “railways, canals, streets, bridges, factories and exhibition halls”.²¹⁹ Behrens implored of the reader, “why (have these methods) not been applied to housing”? Shifting to the more established approach in Germany, the “Taylor-System”, Behrens explained how Taylor’s process consisted of first “studying an isolated task”, such as “Taylor’s study of brickwork”, in order to generate a methodology applicable to “collective work”.²²⁰ Behrens speculated that “scientific management”, under which he included the “Taylor-System” of task study and the “typification” or “standardization” of building components, would assist in the

²¹⁸ More a design treatise than a manual, *Peter Behrens, Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]*, was prepared during late 1917 and published in March 1918. Behrens clearly hoped to gain commissions designing housing for industrial workers involved in Germany’s war effort. His former employer, Emil Rathenau had joined the war effort in 1914, as director of the *Kriegsrohstoffabteilung* (KRA), or the “War Materials Board”, bringing the AEG’s experiences with scientific management into the German bureaucracy. A foreword to the treatise by Bernhard Dernburg (1865-1937), German politician, acquaintance of Rathenau’s and Friedrich Naumann’s, who would join the German Democratic Party (DDP), along with the two of them, reflected Behrens’ continued standing and future ambitions. Significantly less thorough than Muthesius’ manual, the treatise was organized into three chapters. “Savings Through Planning”, was by far the longest chapter, while “Savings Through Technical Construction”, which included the sections “The Scientific Management of the Construction Plant” and “Organization”, was much shorter. Two other short sections on “Savings Through Shared Facilities” and “Building Art Implications” rounded out the treatise, which essentially focused on a single settlement design system, the *Gruppenhausbau*, or “grouped house building”. As I will show in the more detailed discussion of this system in Chapter 4, much of Behrens’ system actually came directly from Raymond Unwin, although the application of his principles, as well as those of scientific management, were hindered by his own rationalistic view of types. There are two brief accounts of this manual, Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*. And Neumeyer, “The Workers’ Housing of Peter Behrens.”

²¹⁹ Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* 59-60. Behrens credited Friedrich Neumann for his understanding of industry, not Muthesius. He also credited Friedrich Paulsen for introducing him to scientific management. Paulsen, was later the editor of *Bauwelt*, and a member of the RFG, where he oversaw the formation of the “experimental settlements” program, starting in 1926.

²²⁰ *Ibid.*, 61. It was actually Taylor’s discussion of Gilbreth’s studies on bricklaying that Behrens was referencing, but the two men became conflated. Taylor’s decision to use Gilbreth’s work to demonstrate the broader application of his principles, outside of the factory, was a clear success, especially among architects, who often referenced Taylor, the Taylor System or *Taylorisme*, when actually discussing Gilbreth’s work. The writing also shows that Behrens was primarily familiar with the 1913 translation of *Principles*.

“industrialization” of both the factory and the building site.²²¹ “Scientific management”, Behrens concluded, “should contribute significantly to economization of small-housing”, a problem he would claim to have resolved in a second article in 1919.²²²

While Behrens’ March 1918 text was likely the first extensive discussion of scientific management by an architect, and certainly a European protagonist of the modern movement, it lacked both the comprehension and familiarity of scientific management demonstrated by Muthesius, and more importantly, it lacked his broader theoretical framing. This comprehension allowed Muthesius to distinguish between the “scientific analysis of construction” and the “systematic management of the construction plant”, as well as the general theories of Taylor and the specific application of these theories to construction by Gilbreth. Most importantly, however, he was able to link his own theories of *Typisierung* and *Typenbau* to scientific and systematic management. Behrens would claim to have applied the principles of scientific management, *industrialization*, *standardization* and *Taylorization*, to settlement design by 1919, as would his former employee, Le Corbusier, in 1926. However, it was Martin Wagner, a German architect who had worked in Muthesius’ office, at approximately the same time Le Corbusier had for Behrens, who could truly claim to be the first German architect to apply Frank Gilbreth’s

²²¹ “Das Taylor-System beabsichtigt also eine möglichst intensive Ausnutzung der Arbeitskraft des einzelnen, wodurch beispielsweise bei Errichtung von Kleinhausbau die Zahl der Arbeiter oder aber auch die Ausdehnung der Arbeitszeit bedeutend herabgemindert werden könnten. So sollte auch die Einführung des Systems der wissenschaftlichen Betriebsführung zur Berbilligung des Kleinwohnungsbaues wesentlich beitragen.” Ibid. In 1914, Behrens had not attacked Muthesius’ call for *Typisierung* but he also did not support it either, claiming that he did not understand the term. For more on this see Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*. Anderson generally follows the argumentation set by Posener, *Anfänge Des Funktionalismus: Von Arts and Crafts Zum Deutschen Werkbund*. Only four years later, Behrens would discuss “typification”, “industrialization”, “organization”, “scientific management” and the “Taylor-System” with relative ease. He did not, however, share Muthesius’ more empiricist leanings in these writings nor in his practice.

²²² Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* 60. That 1919 article, written after Behrens had supposedly applied scientific management to his work is Behrens, “Die Gruppenbauweise.”

experimentally derived standard tools, parameters and methods to a settlement project. Between 1918 and 1920, it would be Le Corbusier who demonstrated a more thorough understanding both of Taylor's "laboratory idea", as explained by Henry Le Châtelier, and of Hermann Muthesius' ideas of typification and arguably type building.

Le Corbusier and Scientific Management, 1918-1920

Le Corbusier, like Peter Behrens, was first introduced to scientific management in 1910 while on a tour organized by Muthesius of the AEG facilities, then functioning under the principles of the "Taylor-System", and later as an employee in Behrens' atelier.²²³ He was again exposed to 'Le Système Taylor' in late 1917, while working with American engineers on the design of slaughterhouses in France, which provoked significantly more interest, as attested in a letter to his parents:

At the moment I am in a competition involving three parties for the military engineers for a large American abattoir... The solution is the opposite of European methods, and it is surprisingly simple and logical. Truly we have our eyes in the back of our heads. ... My life is a paradox: exhausting. By day I am an American (as this designation seems timely) and read Taylor and practice Taylorism.²²⁴

Despite these claims to his parents, there is no evidence of his actually practicing Taylorism and it is highly unlikely as it was a task reserved for specialist engineers. Similarly, neither Behrens, during his work for the AEG, or Albert Kahn, working for Ford during the same

²²³ I will discuss these experiences in more detail in Chapter 4 in relation to the experience of the application of scientific management by Behrens, starting in late 1918, and Le Corbusier, starting in late 1923. The texts reflect the more noumenal experience of exposure to discourse, instead of the phenomenal engagement in "conjecture", through drawings, models and *translations of drawing to building*.

²²⁴ Letter from Le Corbusier to his parents, November 22, 1917. Translated by and published in Brooks, *Le Corbusier's Formative Years*, 486. Brooks, an otherwise rigorous scholar, unfortunately follows Bryan Taylor's example by providing his *original* translation of the French translation of Principles, this time as "Principle of Scientific Management of Factories". Neither, he nor B. Taylor nor Mary McLeod appears to have read Taylor in his or her own native language. Le Corbusier's own understanding of scientific management most certainly came from French sources, many of which were much clearer than Taylor's writings, particularly *Principles*. The most probable source for Le Corbusier was Châtelier, "Le Système Taylor." Châtelier also wrote the introduction to the French translation of *Principles*.

period, engaged in scientific or even systematic management directly, but rather provided specialized services, participating in a system devised by others.²²⁵ With the subject at the forefront of discussions, both by the general public, as well as architects, Le Corbusier's more recent interaction with engineers practicing scientific, or more likely systematic management, provide one potential explanation for the younger architect's more insightful enthusiasm. Le Corbusier, like Behrens, came to scientific management with a set of predefined problems to be resolved, which will be discussed further in subsequent chapters.

In a chapter of his first book, *Après le Cubisme* (1918), titled "L'Esprit Moderne", Le Corbusier asked the reader a fairly broad question, namely, "(w)hat is modern life?"²²⁶ The answer, embedded in a brief history of the past century, started with the "machine", which was "given [to] us by the nineteenth century", "revolutionized work" and "sowed the seeds of a great social transformation".²²⁷ Writing only two years after having moved from La Chaux-de-Fonds, one of the last artisanal centers in Europe, Le Corbusier explained how "serial work, imposed by the (demands) of the machine" had destroyed the older model of production where "each man had created all the parts of the work himself" and as a result

²²⁵ Lindy Biggs, *The Rational Factory: Architecture, Technology, and Work in America's Age of Mass Production* (Baltimore: Johns Hopkins University Press, 1996). Unfortunately this rigorous, archival research has not yet impacted established, and primarily operative, narratives within architectural history-theory.

²²⁶ Jeanneret, *Après Le Cubisme*, 26-28. His mention of Taylor has been cited in a number of articles, but had usually been discussed out of context of the entire brief but dense chapter, the explicit introduction to the series of articles on the "engineers aesthetic" that he would publish in *L'Esprit Nouveau*, from 1920 to 1922, and synthesize into *Toward an Architecture*, in 1923.

²²⁷ "Le dix-neuvième siècle nous donna la machine. En révolutionnant le travail, la machine sème les germes de grandes transformations sociales; en imposant à l'esprit des conditions différentes, elle prépare une orientation nouvelle." *Ibid.*, 26. Here, the mechanization and the industrial revolution are treated as a historical event, one that separates the present condition from the age of craft.

“grew attached to them and loved them as his own creation”.²²⁸ More recently, a new form of “rigorous industrial production” had emerged, providing a new “collective pride”, the “result of a culmination of collective efforts”, and now focused more on “mental work” than simply on mechanization or the “ancient spirit of the artisan”.²²⁹ Le Corbusier described this “transformation ... as progress”, as “one of the important factors of modern life”, and as a “real evolution of work carried out by the utilization of synthesis and order”.²³⁰ Although it had been “pejoratively defined as *Taylorisme*”, Le Corbusier argued, echoing Le Châtelier’s 1914 article on the subject, scientific management was actually the “exploitation of scientific discoveries”, the “substitution of guesswork and empiricism alone, with the scientific principles of analysis, organization and classification.”²³¹

²²⁸ “Autrefois, chaque homme créant son oeuvre de toutes pièces s’y attachait et l’aimait comme sa créature; il aimait son travail.” Here “he” includes Le Corbusier, who had only recently and reluctantly abandoned the search for a living craft tradition. See Passanti, “The Vernacular, Modernism, and Le Corbusier.”

²²⁹ Jeanneret, *Après Le Cubisme*, 26. This later industrial period is characterized by “collective” and “mental work”. It is also the “mental work” of the architect, and not only the “mass production (of) houses” to which Le Corbusier will seek to apply the principles of scientific management.

²³⁰ “Cette fierte collective remplace l’antique esprit de l’artisan en l’élevant à des idées plus générales. Cette transformation nous paraît un progrès; elle est l’un facteurs importants de la vie moderne. L’évolution actuelle du travail conduit par l’utile à la synthèse et la ordre.” Ibid. For Le Corbusier, a trained craftsmen, this is a personal issue more than the societal ideology argued by McLeod and others. Like Taylor and the Gilbreths, experimenting on themselves and their entire family, he will seek to experiment on himself and to standardize his own, often irrational, mental work. The artist-craftsman was no longer the model for industrial production, as he had been for John Ruskin, who finally accepted industrial production, but maintained a clear division between “the skill by which an inventive workman designs and moulds a beautiful cup, is skill of true art” and the “the skill by which that cup is copied and afterwards multiplied a thousand fold, is a skill of manufacture”, in 1858. Ruskin, *The Elements of Drawing: In Three Letters to Beginners*, xi. This was essentially the same argument repeated by Henri van de Velde in 1914, even earlier, in 1910, when Le Corbusier witnessed an early version of the later debate, according to Brooks, *Le Corbusier's Formative Years*, 220. The primary ontological model was now the collective mental work within the plant. Le Corbusier applied this model to his own design practice, not to his political views.

²³¹ “On l’a définie “taylorisme”, et cela dans un péjoratif. A vrai dire, il n’était question d’autre chose que d’exploiter intelligemment les découvertes scientifiques.” While certainly generally attributable to Taylor, the tone and wording is very close to Châtelier, “Le Système Taylor.” Le Corbusier’s more rationalistic tone towards “empiricism” will also change in the subsequent text on the subject, in 1920, and in his practice, after 1923, but it will return after the dramatic conclusion to his “Balzac-like” drama in Bordeaux in 1929.

Half a century earlier, the mechanization *revolution* destroyed craft culture²³²; while negative in many respects, Le Corbusier acknowledged that it had also given rise to new tools and artifacts, the “embryos of an architecture to come.”²³³ Now, that same “esprit nouveau”, the title of his subsequent journal, had not only matured but had been recorded by Taylor. That “spirit” of *organization*, not simply mechanization, “enabled one to see clearly”, and not “since Pericles had the mind been so lucid”.²³⁴ Le Corbusier explained it was not the means of production that had been lacking during the 19th century, as “bridges, factories, dams and other gigantic structures”, the “germs of future development” in which one “sensed a Roman grandeur”, were proliferate in the realm of engineering. It was architects who lacked the *eyes to see* an aesthetic sensibility and access to the principles with which these artifacts had been conceived.²³⁵ These principles of “order and synthesis” now had the potential to displace “the Academy”, at whose hands “architecture would be dead” if not for the “happy detour” suggested by “engineers and builders”.²³⁶ Here, Le Corbusier clearly advocated for a shift not in the way that architectural artifacts were

²³² The section header “architecture or revolution”, used in *Toward an Architecture* (1923), presents architecture as an ordering device, a critical response to mechanization.

²³³ “...embryons d'une architecture à venir...” Like Muthesius, Le Corbusier discussed the implications of already existing “construction” systems, as *embryos* for architectural experimentation and standardization. He would focus on the technical issues of architecture, including space planning and project delivery, adopting fabrication and construction techniques already used in American workers’ housing delivery.

²³⁴ The roots of this reference to Hellenic architecture here, and in the 1920 article I will discuss below, as an example of the same unconscious and collective evolution and adaptation visible in modern industry, and vernacular architecture, to the discourse of the Werkbund and Muthesius has already been explained, most recently in Passanti, “The Vernacular, Modernism, and Le Corbusier.” What has not been discussed, and is more evident here than in the 1920 article, is Le Corbusier’s equation of Taylor’s principles, as the logic behind the conscious, individual logics behind modern industry, with the real principles of Hellenic architecture, which he had learned through Auguste Choisy, *Histoire De L'architecture* (Paris: Serg, 1976 (1889)). Like Muthesius, in his brief discussion of the formal qualities of a temple façade, Choisy also read the models of classical architecture through the lens of romanticist theory, emphasizing the consciously “picturesque” and “asymmetrical” qualities of temple precinct groupings.

²³⁵ Here, Le Corbusier uses “germ” as another metaphor for the tentative standard, the type to be evolved and adapted. In 1920, he would be more explicit about the aesthetic sensibility needed to appreciate and participate in diachronic time, since architects lacked the “eyes to see” this in seemingly static objects.

²³⁶ Essentially the same argument is made in Muthesius, “Neues Ornament Unde Neue Kunst.”

fabricated but in how they were conceived, through a process of graphic projection and project management, following the recently codified principles of engineering *composition*, offered by Taylor.

In addition to Taylor and Le Châtelier, Le Corbusier echoed another important influence in this text, Raymond Unwin, whose *town planning* principles he had been studying since 1910.²³⁷ In 1911, Unwin explained that his settlement design manual had been based upon and would now make available “those principles of organization the application of which to our great industries during the past century has led to such increased efficiency.”²³⁸ Previously, these principles, which had provided such agency to industry during the latter half of the twentieth century, had not been available either to design professionals or to “urban communities”. Le Corbusier made a similar comment in his 1918 text, contrasting the “chaotic suburbs of cities” and the “harmony ... approaching beauty” found in industrial plants and largely resultant of the “purity of principles that guided their construction.”²³⁹

In looking for the application of these principles within construction, Le Corbusier pointed specifically to reinforced concrete, the “latest construction technique”, as the site where these principles had already been applied, since the material was ideally suited to the “implementation of rigorous calculations”. With the help of these standard parameters,

²³⁷ Bryan Taylor, Robert Fishman and Allen Brooks have all discussed this important influence on Le Corbusier. The most thorough assessment is included in the introduction to Charles-Edouard Jeanneret, *Le Construction Des Villes* (La Chaux-de-Fonds 1987 (1910)). I will deal with this issue in detail in Chapter 4.

²³⁸ Raymond Unwin, "Introduction to the Second Edition," in *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1911). In his own studies of Unwin's work, Le Corbusier showed a comprehension of how projects like Hampstead Garden Suburb related to earlier “garden villages” like Port Sunlight and Bournville, settlements that grew out of and were also connected to industrial plants, producing soap and chocolate. Jeanneret, *Le Construction Des Villes*, 60.

²³⁹ Jeanneret, *Après Le Cubisme*, 29. He would return to this subject, in detail, in Corbusier, "Maisons En Série." I will discuss this article in detail in Chapter 4.

extracted by engineers, the “number, which is the basis of all beauty, could now find expression,” in the hands of the architect.²⁴⁰

Le Corbusier also echoed Muthesius’ characterization of industry as a new vernacular, whose “*sachliche* progress” was collective, knowable and highly accelerated. Le Corbusier argued that “machines,” “governed by numerical parameters,” had “evolved more rapidly,” and were therefore “now reaching a remarkable degree of purification”, one that elicited a “new sensation, a new delight”. The “importance” of the application of these principles and this accelerated process of collective evolution was a “new factor in the conception of modern art.”²⁴¹ Later in the book, Le Corbusier would explain that “Purism”, his alternative to Cubism, was not “intended to [be] a scientific art, (a concept) which made no sense”, but rather a new means of producing and seeing through these processes.²⁴² He would emphasize the same distinction, between a rigorous framework of investigation and

²⁴⁰ Jeanneret, *Après Le Cubisme*. Taylor, working closely with Sanford E. Thompson, had in 1905 published experimentally derived standards for concrete mixes and curing times; these standards were often cited in the concrete housing construction manuals that Le Corbusier was referencing at this time. Thompson, *A Treatise on Concrete, Plain and Reinforced*. This manual was used by engineers in Europe and America by World War I, along side Emil Morsch's *Der Eisenbeton* (1909), discussed by Jean Louis Cohen in Jean-Louis Cohen, "The Dom-Ino Intrigue," *Log* 30(2014). Le Corbusier’s more general calculations, usually done through orthographic projection, not formulas, were more directly informed by manuals like Maurice M. Sloan, *The Concrete House and Its Construction* (Philadelphia: The Association of American Portland Cement Manufacturers, 1912). This manual dealt with tectonics and aesthetics, not only numbers and charts. I will discuss this in Chapter 4.

²⁴¹ “Déjà les machines, à cause même de leur conditionnement par le nombre, avaient évolué plus rapidement, atteignant aujourd’hui un épurement remarquable. Cet épurement crée en nous une sensation nouvelle, une délectation nouvelle, dont l’importance donne à réfléchir; elle est un nouveau facteur dans le concept moderne de l’Art.” Jeanneret, *Après Le Cubisme*. Here Le Corbusier combines aspects of Le Châtelier’s 1914 discussion with the broader theories of Muthesius. Muthesius himself was never as explicit about this simple fact: not only were modern engineers practicing a conscious form of typological evolution and adaptation, admired in vernacular architecture, but this was happening much more quickly, measurable in years, not decades or centuries.

²⁴² “Le Purisme n’entend pas être un art scientifique, ce qui n’aurait aucun sens.” *Ibid.*, 59. Purism, like Unwin’s town planning, Muthesius’ theory of type and Choisy’s reading of the picturesque tendencies of Hellenic architecture, returned to more radical romanticist sources in order to move forward, particularly the work of Paul Cezanne (1839-1906), whose own critique of “pernicious classicists” and admiration of gothic art and vernacular urbanism also led to the development of “by the logic of organized sensations, which provide the means of expression.” Lawrence Gowing, “The Logic of Organized Sensations,” in *Cezanne: The Late Work* (New York: MoMA, 1977).

a more intuitive decision making process, informed by that framework, in his later *laboratory work* in Bordeaux.

Le Corbusier concluded his discussion of the “new spirit” of Taylorism by offering a conceptual matrix, one that linked models, modes of conjecture and means of material production of architecture and industrial engineering. He explained that during the age of Pericles, Greeks had demonstrated a similar “understanding of the spirit” of synthesis and order now found in the principles of scientific management. However, they had lacked the “method and means comparable to those of modern industry.” During the 19th century, the machine had destroyed the “ancient spirit of the artisan”, just as “scholasticism” was retarding the architectural discipline. Now, the introduction of *organization* to mechanization and the codification of industrial engineering principles, by Taylor, made them available to architects. Builders had already used these principles on works such as the “Pont du Gard”, but architects had not.²⁴³ In time, forecasted Le Corbusier, architects “will also have (their) Parthenon” since the current period was “better equipped than Pericles to [realize] the ideal of perfection”, an issue he promised to return to in, “a forthcoming volume of “Comments”.²⁴⁴ That volume was published in 1920, the same year that Muthesius revised his discussion of Typenbau.

In his 1920 article, “The Eyes That Do Not See ... III: Autos”, Le Corbusier finally synthesized Muthesius’ earlier theories of typification and type building with that of the

²⁴³ Le Corbusier’s point here is that, builders, civil or construction engineers, had already produced works of great beauty, using these principles of conjecture and making, but architects had not. Taylor had not invented a new system of production, such as the assembly line, he had invented a new system of projection, based on the principles used by various engineers, in industrial production and infrastructure. This observation closely aligns with the history of systems thinking covered in Peters, *Building the Nineteenth Century*: .

²⁴⁴ Here, Le Corbusier is announcing the continuation of this discussion through the *L’Esprit Nouveau* articles, making this section of *Après* the “embryo” of *Toward an Architecture*.

“new spirit” of Taylorism, particularly the laboratory method.²⁴⁵ The synthesis of those ideas in this article mark an important point in the architect’s career, both historically and theoretically, between the theories of scientific management as well as typological evolution and the architect’s refinement of his own-settlement design approach.²⁴⁶ In the first issue of *L’Esprit Nouveau*, Le Corbusier elaborated on ideas from the 1918 text, explaining that “there is a new spirit”, a “spirit of construction and synthesis, guided by a clarity of conception”.²⁴⁷ In 1920, he would discuss the two related activities of the laboratory method, the “establishment of standards” through “experimentation”, and the gradual evolution of that standard towards a type, through engagement with various contingencies, “standardization”.²⁴⁸

²⁴⁵ Le Corbusier, "Des Yeux Qui Ne Violent Pas... Iii: Les Autos," *L’Esprit Nouveau* 10(1920). Significant portions of this text, particularly regarding the Parthenon, were repeated and expanded from *Après le Cubisme*, while other parts, particularly the discussion of housing and the Loucher Program for affordable housing, which he would repeat in "Maisons En Série." were removed from this section, starting with the 1923 edition as well as in the definitive, 1928 edition. "Des Yeux Qui Ne Violent Pas... Iii: Les Autos," in *Vers Une Architecture* (Paris: G. Crès et cie., 1928). This section is included in the 1927 English translation, "Eyes Which Do Not See: Iii Automobiles," in *Toward a New Architecture* (Oxford: Architectural Press, 1998 (1927)). It is also included and revised in the 2007 English translation, "Eyes That Do No See ... Iii Automobiles," in *Toward an Architecture*, ed. Jean-Louis Cohen (Los Angeles: Getty, 2007 (1998)). The same material is also included in the 1926 German translation, *Kommende Bau Kunst* [Vers une architecture], trans. Hans Hildebrandt (Stuttgart: Deutsche Verlags-Anstalt, 1926; repr., 1965).

²⁴⁶ "Des Yeux Qui Ne Violent Pas... Iii: Les Autos." This was the first use of the terms “standard” and “standardization” by Le Corbusier, as he would acknowledge in *The Marseilles Block* [L’unité d’habitation de Marseille], trans. Geoffrey Sainsbury (London: The Harvill Press, 1953 (1950)), 30. “In 1920 *L’ESPRIT NOUVEAU* proclaimed that it is the discovery of a standard which leads to perfection.” I will discuss this passage later in this text. Le Châtelier did not use the term “standard” in his 1914 text, equating it with the French term *mesure*, or “measure”, a term Le Corbusier also used as distinct from standard, and equated with the term “type”.

²⁴⁷ He cited this article in a footnote in the 1920 article.

²⁴⁸ In the original article, the point was made throughout the text and then summarized in the conclusion. In *Vers une Architecture* (1923) Le Corbusier added a short text at the beginning of the article, explaining the basic process he would be describing, a slightly modified version of the conclusion. So the first sentence in 1920 read “Il faut tendre à l’établissement de standarts pour affronter le problème de la perfection.” Translated in Cohen, 179, as “We must see to the establishment of standards so we can face the problem of perfection.” Instead of “see”, tend or strive, could also be used here. In the later versions of this text, starting in 1923, the term “definitive” is added to “establishment of standards”, which is somewhat contradictory to Le Corbusier’s own discussion of standardization as well as to the discourse of scientific management, which insisted on standards being tentative, not definitive. This also contradicts Le Corbusier’s own application of these principles in his own work.

Immediately preceding, “automobiles”, the third installment of the “eyes that do not see” series, Le Corbusier provided his readers with images contrasting academically conceived contemporary buildings with the products of industry, conceived through the principles of the “new spirit”.²⁴⁹ (Fig. 04) Then, as an attack on Academicism, he proceeded to explain the theories of Muthesius and Taylor through the *model* of Academic composition, the Hellenic Temple. Instead of the earlier use of the terms “number” and “measure”, in 1918, attributable to Le Châtelier, or type and norm, used by Muthesius, Le Corbusier chose to use the “Anglo-Saxon”²⁵⁰ term most often utilized by Taylor and his associates, “standard”. Following a logic already used by Riezler and Muthesius, as well as discourse attributable to Taylor and Gilbreth, Le Corbusier argued that “we must see to the establishment of standards so that we can face up to the problem of perfection.”²⁵¹ While no individual could invent a standard, they had the capacity to identify standards and could therefore actively contribute to the further *establishment* of that standard, a process Muthesius first called *typification*, or the *evolving of types*, but which Taylor and now Le Corbusier would call “standardization”. Standardization did not simply mean the

²⁴⁹ Le Corbusier, “Des Yeux Qui Ne Violent Pas... li Avions,” *L’Esprit Nouveau* (1920). Le Corbusier paired six examples of “scholastic” architecture, in a variety of historical styles, captioned “The problem poorly posed” on the top of the page and “The Eyes that have not seen...” on the bottom of a page, with an image of the side view of an airplane, whose only caption was the company that made it, “Farman”, the Farman Aviation Works. Whether Le Corbusier knew that Henry Gantt had helped innovate the production of concrete-hulled war ships for the Emergency Fleet Corporation, between 1917-18 is not clear. In *Toward an Architecture*, these images would appear immodestly before the “Autos” article, on pages 125-126 in Etchells/Rodker, and 174-175 Goodman/Cohen.

²⁵⁰ *The Marseilles Block*, 30.

²⁵¹ “Il faut tendre à l’établissement de standarts pour affronter le problème de la perfection.” “Des Yeux Qui Ne Violent Pas... Iii: Les Autos.” In Cohen, 179.

application of an established ideal, type or standard, first and foremost it meant the development of a standard.²⁵²

Returning to Le Corbusier's discussion of the Parthenon, he explained that it was the "product of selection applied to an established standard".²⁵³ The term "selection" reflects particular choices made by the authors of that specific project, in working within an already defined set of parameters, as well as natural selection, related to evolution and adaptation, that "already for more than a century, all of the elements of Greek temple had been organized".²⁵⁴ In the accompanying images, Le Corbusier presented one of the temples at Paestum, which he dated as having been developed from 600 to 550 BC, as the moment when the standard was established, with all of its elements organized.²⁵⁵ "When that standard has been established", he concluded, "direct and fierce competition comes into play," referring to the process of standardization and choice as "a match", or a game, that, in order "to win, one had to beat his opponents in all matches, in the overall lines of

²⁵² It was for this reason that Gilbreth had clarified the tentative nature of standards, things that were identified in the world and/or experimentally derived to serve in the process of standardization, but might only in very certain instances lead to a "superstandard".

²⁵³ "Le Parthénon est un produit de sélection appliquée à un standart établi." Translation from Cohen 180. Later in the text, he discusses market forces and speculation as a form of man-made natural selection. Here the irrationality of entrepreneurial speculation will be compared to that of artistic sensibility. He would follow up in 1923 with an article further discussing the issue of "classification", a more objective and rational process, and of "choice" a more subjective and intuitive one, in Le Corbusier, "Classement Et Choix," [Classification and Choice.] *L'Esprit Nouveau* 22(1923).

²⁵⁴ In the original 1927 English translation by Frederick Etchells the term "standardized" had been used for "organized". Translation from Cohen 180.

²⁵⁵ For a discussion of the significance of Paestum in earlier critiques of Academicism, see Barry Bergdoll, "The French Academy in Rome, 1826-1832: Laboratory of Romantic Historicism," in *Leon Vaudoyer: Historicism in the Age of Industry* (Cambridge: MIT Press, 1994). Here, Bergdoll argues that Henri Labrouste sought out Paestum as a "testimony to the progressive history of a society arriving on new shores, implanting its traditions, and rapidly adapting them to new materials, to a new climate, and ultimately even to the new social needs that arose with this new life far from Attica. Hermann Muthesius admired Labrouste for similar reasons. Muthesius, *Style-Architecture and Building Art: Transformations of Architecture in the Nineteenth Century and Its Present Condition*, 73.

the *ensemble* and in all the details.”²⁵⁶ In contrast to the more analytical process of experimental definition of standard and the organization of its parts, the process of further standardization is here characterized as a “match”, following Taylor’s earlier distinction between that of scientific analysis and that of artistic management. “Progress”, in the 1918 article, was associated with the application of the new principles of industrial organization, but by 1920, the term “progress” was associated with the accelerated evolution and adaptation through the engagement of mass production, speculation and mass consumption. Like artistic conjecture, these generative forces were irrational.

Offering an argument similar to Muthesius’ dual approaches of *type building* and *building with types*, Le Corbusier explained that standardization implied the “extensive study of all the parts”, essential to “progress”, as well as the use of standards to systematically manage work, as a means to prevent “arbitrariness” for the manager and the managed, for the producer and the consumer.²⁵⁷ The initial “establishment of a standard” would develop into a “recognized type” over time.²⁵⁸ While the Parthenon was to be admired for the refined *selectiveness* of its particular authors, it was only a revered

²⁵⁶ “Lorsqu’un standart est établi, le jeu de la concurrence immédiate et violente s’exerce. C’est le match; pour gagner, il faut faire mieux que l’adversaire dans toutes les parties, dans la ligne d’ensemble et dans tous les détails. C’est alors l’étude poussée des parties. Progrès.” Corbusier, “Des Yeux Qui Ne Violent Pas... l’ii: Les Autos.” In the Cohen translation, the portion I have italicized, “of the ensemble” is omitted. I have returned this important phrase because it is repeated again in “Maisons en Serie”, but this time the “parts” are the individual housing units, in series, and not the technical elements of an automobile, and the “ensemble” is the spatial and temporal settlement artifact and experience, not the moving automobile.

²⁵⁷ In this discussion of standardization, Le Corbusier covered the full range of the laboratory method, experimentation and standardization, under a single term; one was not making experiments, one was making standards. Translation from Cohen 181.

²⁵⁸ Translation from Cohen 182. Here, “standard” is used to mean a *tentative standard*, while “type” is used to mean a *superstandard*. Le Corbusier would use the same definition thirty years later in Corbusier, *The Marseilles Block*. While the principles of academic composition, such as regulating lines, would continue to be applied by Le Corbusier, as a corrective measure, this presented a definitive break with the essential ontology of Academicism, especially as defined by Quatremere de Quincy and paraphrased by Barry Bergdoll as the “the primacy of the idea over the material in all the fine arts, of the universal over the specific in the search for subject matter, and of the eternal over the ephemeral”, one that began in a century earlier and that was now reinforced by the ontology of industrial production. Bergdoll, “The French Academy in Rome, 1826-1832: Laboratory of Romantic Historicism,” 80.

contribution to the overall process of standardization from an established standard to a recognizable type. Here there is an implicit, but intentionally vague, distinction between what Muthesius had explained as the evolution of a technical unit form versus the achievement of *artistic unity*, a feat founded on a knowledge of and participation in type building but also a kind of dead end, valued for its uniqueness.²⁵⁹ Identifying the pinnacles of artistic unity was a key skill, one that had already been defined by Academicism, but the ability to identify the right *germs*, *embryos* or *kernels* that showed the promise of evolving from standards to types was a new skill. This skill, which Muthesius and Le Corbusier had tried to learn from vernacular architecture and from industrial production, would now be explained through the manuals of scientific management.

To illustrate the process of evolution and selection, and not only as an aesthetic or tectonic model, Le Corbusier turned to a *regional* example, the French auto industry.²⁶⁰ He explained that cars had evolved with two criteria in mind, namely “the simple function (to roll)” and the “complicated one (comfort, aerodynamics, appearance)”, into two distinct variants, the race car, built for speed, and the limousine, built for comfort, but that they had been established through the same process of standardization.²⁶¹ While purely rational concerns led all “automobiles [to] have essentially the same arrangements”, or *organization of elements*, the standardization of the motor-car and its progress towards *perfection* of the parts and *harmony* of the whole ensemble, was not simply the result of deductive, rational

²⁵⁹ Le Corbusier distinguished between a “house” as a “product necessary to man” and a “painting”, a “product necessary to man in order to answer the needs of a spiritual order.” Cohen 182. He provides a list of the “great standards of the heart”, painting with typical subjects, very similar to the examples given by Muthesius in “Der Typenbau”.

²⁶⁰ The choice of a number of small French car companies, instead of Ford or Citroen, here is no coincidence, but instead reflects the idea that even the general types of industrialization have local variants.

²⁶¹ Corbusier, “Des Yeux Qui Ne Violent Pas... Iii: Les Autos.”

calculation, but instead that of “relentless competition *between* the countless firms.”²⁶² It was in the work of entrepreneurs and managers, the *engineers of men and capital as well as materials and forces of Nature* that Le Corbusier saw the principles, which could finally contribute to the “birth of a new style”.²⁶³

The *games* of enterprise and the art of management were related to, but distinct from, the “establishment of a standard” and the “organization of rational elements”.²⁶⁴ This more rational approach required a temporary suspension of aesthetic criteria; with “form and appearance” not being “preconceived” but instead a “result” of this process.²⁶⁵ As such, many early “standards” had a “strange look at first sight”, just as early motor-cars, like the included example of the 1907 Humbert which suffered both from the borrowed form of the carriage, as well as from a lack of synthesis between *organized elements*. However, as Corbusier implied, (albeit less explicitly than Muthesius) harmony, perfection, and beauty could be achieved only through engagement with everyday, often irrational, culture, not merely through rational analysis and calculation. Reflecting his own continued admiration for living vernacular traditions, Le Corbusier pointed to the Brittany to say, “if there are still Breton cupboards there”, it is because the region is “remote” and its population “stable”, still “occupied with fishing and animal husbandry.”²⁶⁶ In most cases, less remote vernacular culture had not been able to contend with the rapid rate of change brought on by mass

²⁶² Ibid. Translation from Cohen 182-83

²⁶³ Ibid. Translation from Cohen 183. As Lindy Biggs has noted in her study of industrial engineering, the new engineer followed what Le Corbusier called the Law of Economics, not the Law of Nature or of Mathematics alone.

²⁶⁴ Ibid. Translation from Cohen 183

²⁶⁵ Ibid. Translation from Cohen 183

²⁶⁶ Ibid. Translation from Cohen 184 He would use images of Brittany in “Vers La Ville Radieuse - Vivre! (Habiter),” *Plans* 4(April 1931). A similar point is made in *Ville Radieuse* (1935), 137. “Etats de culture de la dispersion: les 'folklores'. La parfaite harmonie, un accord parfait sur l'homme. Sérénité des vies pastorales. Outillage preciaire mais suffisant ... Mais la locomotive viendra ou est venue ... Mort des 'folklores', aube angoissante d'une nouvelle culture.” As Passanti has pointed out, the vernacular would remain a conceptual model for Le Corbusier throughout this period.

production and consumption, as he had learned on his travels east.²⁶⁷ Through the writings of Hermann Muthesius, Le Corbusier had already learned of the theoretical possibility of consciously participating, as an individual architect, in the collective production of contemporary vernacular types. With the assistance of Taylor's discourse, he now sought to explain these principles that had informed the evolution of Hellenic temples and in French automobiles, to those who had *eyes that could not see*, Academically trained architects:

Architecture *develops* on standards. Standards are things of logic, of analysis, of scrupulous. Standards are based on a problem well posed. Architecture is plastic invention, it is intellectual speculation, is higher mathematics. Architecture is an art of great dignity. The standard, imposed by the law of selection, is an economic and social necessity. Harmony is a state of accord with the norms of our universe. Beauty dominates *both*; it is a pure human creation; it is a necessary superfluity only for those with elevated souls. But we must first see to the establishment of standards so we can face up to the problem of perfection.²⁶⁸

Just as Taylor had separated the experimental derivation of standards, *experimentation*, something that he saw as more scientific, from management, something he saw as more of an art, that could become more rigorous through more rigorous standards, but was not actually scientific, so too would Le Corbusier separate the *establishment of a standard*, from architectural practice. Standardization, on the other hand, just like management, assisted by an experimentally derived standard, was a process that could go in tandem with architectural practice, in fact the two needed one another. In subsequent texts, Le Corbusier would specifically distinguish the act of defining an architectural element as

²⁶⁷ Passanti, "The Vernacular, Modernism, and Le Corbusier." Le Corbusier discussed his disgust with the death of folk culture in the Balkans in Le Corbusier, *The Decorative Art of Today* [L'art decoratif d'aujourd'hui] (London: Architecture Press, 1987). The role of the train, as the bringer of cheap mass produced products in this discussion is identical to a passage from Raymond Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1909). Le Corbusier had studied this manual since 1914, possibly as early as 1910. I will discuss this relationship in Chapter 4

²⁶⁸ Translation from Cohen 189-90, with two modifications, in italics. The term "normes", used here and in the discussion in relation to the Parthenon, is distinct from standards; these are rules, in the case of aesthetics, proportions, that function as more external parameters, as opposed to standards, which can be established, evolved and discarded.

more of a rational process, similar to the establishment of a standard, and the grouping or arranging of those elements in spatial and temporal ensembles, as a more tumultuous and chaotic process.²⁶⁹ This design process was also compared to playing a game, namely Dominoes. This individual, more conscious game was therefore described as having the same relationship to individually established standards, as the more collective *fierce competition* that takes place when a more general standard, such as a temple layout, is established simultaneously by individual city-states, or the same basic organization of automobile parts, is established simultaneously by individual companies. These more irrational forces generated evolution and adaptation. The social space of more or less regulated industrial capitalism was a kind of laboratory at one scale, working in tandem with the settlement, the architectural atelier and the mind of an individual practitioner. In this text, Le Corbusier not only interprets scientific management through the culturalist lens offered by Hermann Muthesius' earlier theories, as a number of scholars have already pointed out, but he goes even further than Muthesius in considering what this approach might mean for design practice. In Chapter 4, I will discuss the only game of dominoes played by Le Corbusier in social space, his series of experiments near Bordeaux, the Maison du Tonkin, the Lege settlement and the first phase of the Quartiers Modernes Fruges, *conceived, constructed and settled in series*, between 1923 and 1926.

Conclusion

In spite of their diverse backgrounds and experiences with industrial management, the individuals I have discussed in the first portion of this chapter, including Frederick Taylor, Henry Gantt, Frank Gilbreth, Lillian Gilbreth, as well as Daniel J. Hauer, Henri Le

²⁶⁹ Corbusier, "Maisons En Série." "Classement Et Choix."

Châtelier, and Aleksei Gastev, used some variant of what Francis Copley has termed the laboratory method to distinguish between scientific management and other forms of modern industrial management. Taylor's earlier discussions of these principles, between 1903 and 1911, were further clarified but also transformed by others, such as Le Châtelier in 1914, and Frank Gilbreth, between 1914 and 1917. They all emphasized the importance of situating knowledge production within the social space of the factory, with some even beginning to discuss the expanded social space of consumption. They all saw the laboratory method as consisting of two related activities, experimentation and standardization, the former constituting a more controlled and individual study of a process, resulting in a tentative standard, and the latter constituting the study of an experimentally derived tentative standard applied to the work of multiple individuals in the less controlled environment of the factory floor, as well as outside of the factory gates. They theorized a new discipline, that of the industrial engineer, whose general understanding of mechanical, structural and chemical engineering had to be augmented by the incorporation of skills from other disciplines, including economics, psychology and sociology, with some, like Frederick Taylor, lacking any training in these fields, while others, like Lillian Gilbreth, holding advanced degrees. The laboratory method had first been developed for the factory, where it was applied to an already systematically managed space of production by the industrial engineer, who was to serve as an *engineer of men and capital as well as materials and forces of Nature*, replacing the remaining customary conventions of rule-of-thumb, as well as academically derived theories not adequately tested in situ. It was precisely this heterogeneous background of the pioneers of modern management, as well as the generalist approach that they were advocating, that appealed to the architects that I have

discussed, for all of whom Taylor and Gilbreth were the first engineers, and in most cases the only ones, that they would ever refer to by name.²⁷⁰ Within a discussion that Norbert Wiener has so aptly called the *human use of human beings or programing* in the factory, he demonstrates that early industrial engineers attempted to retain an authority based on the natural sciences, while at the same time engaging the social sciences. However, as the father of cybernetics would later caution, these fields could not be studied with the same instruments of data analysis that engineers had applied to the study of material properties and structural forces²⁷¹; in this way, they moved closer to the discipline of architecture, which kept its own unresolved, but deeply productive relational position between science and art. More so, industrial engineers began to consider three issues that architects could easily recognize as being central to their own discipline: the production of protocols for production, the management of production, through the utilization of those protocols, and the creation of tools, at the scale of a building, such as an individual factory, and at the scale of an urban ensemble, such as the industrial plant. While these practices had existed within the various engineering sub disciplines since the 18th century, just as the preparation of drawings and the management of construction had existed in building before the 15th century, the difference was that now these principles had been codified, making them easier to translate to another discipline, although not necessarily to apply.

²⁷⁰ Henry Ford would also be frequently discussed, particularly after the translation of his autobiography in 1923, but often as an example of the successful application of the principles associated with Taylor and Gilbreth.

²⁷¹ Wiener, *The Human Use of Human Beings: Cybernetics and Society*. Wiener discusses here how Darwin's evolutionary theories provided an alternative to the earlier theories of progress of the Enlightenment, themselves a secularized version of earlier religious theories of progress. Evolution and adaptation are closely linked to theories of control and feedback. The goal for Wiener was not to develop automation based on the machine but based on the social organization of the factory.

While few architects in America and Europe were unaware of the significant changes underway in industrial production around 1918, the three architects I have discussed, Peter Behrens, Le Corbusier and Hermann Muthesius, not only discussed the general appearance of the industrial engineer or modern, American, systematic or scientific management, but they focused on the laboratory method. Through Hermann Muthesius' writings on the relationship between the architectural production of the individual architect and the evolution and adaptation of types in time and place, I have sought to explain how these three architects were able to focus on and comprehend the laboratory method from a myriad of sources, many of which were not particularly clear. I have also sought to distinguish the degree of this comprehension and the way that these individuals considered the application of this ontology to the architectural production of specific works or more general types and even to a contemporary style. Following Stanford Anderson's arguments regarding Peter Behrens' failure to "fully grasp... the possibility of creatively developing norms", with the assistance of Hermann Muthesius' theories, I have similarly found that Behrens failed to fully grasp the full potential of the laboratory method, despite his early and extensive exposure to the application of scientific management. Muthesius' own theories also explain why that architect was able to so easily connect his earlier theories of *sachlich progress*, *typification* and *type building* with scientific management in 1920. Following Anderson, Passanti and Allan Brooks' research on Le Corbusier's comprehension and further development of Hermann Muthesius' theories, I have also shown how those theories, in addition to a number of other factors, most specifically access to Henri Le Châtelier's clear and thorough discussion of the laboratory method, help explain that architect's early discussions of *Taylorisme* in 1918, only a few months after

those of his former employer, and his more thorough discussions of the *establishment of standards*, or experimentation, and standardization, through individual practice, towards more generally valid, but also temporally and geographically specific types, in 1920. That same year, one of his theoretical mentors, Hermann Muthesius, made a very similar link between type theory and scientific management. Both Hermann Muthesius and Le Corbusier made a distinction between the more analytical and rational formulation of *technical unit forms*, or *standards*, and the more artistic or plastic formation of *artistic unit forms*, or harmonic ensembles, as two related but distinct areas of architectural production. However, in 1920, Le Corbusier went further in equating the more collective forces of evolution and adaptation of industrial capitalism at one scale and the more individual forces of evolution and adaptation within a given translation from thought to drawing, drawing to building, and building to social organization and aesthetic experience, to one another, than Muthesius. These theories would be fully theorized in the 1922 article, “Maisons en Série”, where Le Corbusier would describe how the “modern spirit” and the “engineers aesthetic” that had developed during the nineteenth century and had been formalized, by Taylor, at the turn of the twentieth century would now inform the “conception, construction and dwelling of houses in series”; three equally relevant activities of standardization, or the development (not application) of standards, at the scale of an individual architectural practice, and of the evolution and adaptation of types, at the scale of a region, nation, industry or epoch. I will discuss this article in more detail in Chapter 4. Before I turn to this discussion, I will explain the ‘visualization theory’ and accompanying instruments developed by Taylor, Gantt and especially Gilbreth to assist in experimentation and standardization in Chapter 2.

Chapter 2. Visualizing the Laboratory Method: Frank and Lillian Gilbreth, 1906-1922

In Chapter 1, I discussed the *general way of viewing the production process* of scientific management, the laboratory method. In this chapter, I will discuss a *set of specific practices* developed by members of the Taylor Circle, between 1901 and 1917, to assist in the tasks of experimentation and standardization. These practices were linked with new instruments of notation, visualization and projection, which drew on and modified existing methods of orthographic projection, common to architecture and engineering, data visualization, used by economists, and motion study, developed by physiologists during the late 19th century.²⁷² While, Frederick Taylor, a toolmakers apprentice, had a limited role in this field, he developed the instruction card, an instrument for notating, analyzing, projecting and managing a particular task, primarily through temporal parameters, which had been initially developed for experiments in machine operation.²⁷³ Henry Gantt, Taylor's associate on his two most important consulting jobs, developed the first instrument to assist in the standardization process, the graphic daily balance for manufacture, now known as the Gantt chart.²⁷⁴ The Gantt chart acknowledged and institutionalized the tentative nature of the standard by recording and visualizing its initial experimentally derived parameters against those of conventional practice on the shop

²⁷² The two most thorough discussions of the instruments of scientific management, as related to those of other disciplines are included in Sigfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* (New York: Norton, 1974 (1948)), 145-46. and in Tom F. Peters, *Building the Nineteenth Century*: (Cambridge: The MIT Press, 1996). Giedion focuses on the physiological disciplines while Peters focused on economics and orthographic projection.

²⁷³ The instruction is most similar to a contemporary computer program, particularly the BASIC language. For an explanation of the influence of Taylor and the Gilbreths on computer science, see Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society*, Da Capo Series in Science (Boston: Houghton Mifflin Company, 1954 (1950)).

²⁷⁴ The Gantt chart is still the most widely used graphic project management system in the world. For a good explanation of its contemporary use see Stuart G. Walesh, *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields* (Hoboken: Wiley, 2000), 145-46. or Kathy Schwalbe, *Information Technology Project Management* (Cengage Learning, 2010), 228. The most significant difference is that today, the Gantt chart is a computational, as well as graphic, projection instrument.

floor, exceeding the scope of the instruction card by not only acting as a control measure, but as a form of feedback, used to further refine the standard itself. These two early instruments of experimentation and standardization, the instruction card and the Gantt chart, both of which were first published in 1903²⁷⁵, were then further refined and synthesized by two other members of the Taylor Circle, Frank Gilbreth, a former building contractor, and Lillian Gilbreth, a trained psychologist. Between 1912 and 1914, the Gilbreths would publish, through a series of articles and manuals, a more complete “visualization theory” of industrial production.²⁷⁶ While Taylor and Gantt preferred the instruments of economics and emphasized temporal data, Frank Gilbreth retained and expanded orthographic projection, augmenting it with the visualization practices of physiology, many of which utilized photography and film. Whereas the two mechanical engineers developed their approaches through the study of an isolated machine operator, in experimentation, and the already highly controlled space of the factory, in standardization, Gilbreth had developed his approach to experimentation and standardization through the studies of collective, primarily manual, work executed in the

²⁷⁵ While Taylor already discussed the basic procedure in which the instruction card was used in 1895 he first used the term and provided an example in Frederick Winslow Taylor, "Shop Management," *Transactions of the American Society of Mechanical Engineers* XXIV(1903). Gantt published an article on his approach that same year, crediting Taylor more than he probably deserved, for his involvement in its development, Henry L. Gantt, "A Graphic Daily Balance in Manufacture," *ibid*.

²⁷⁶ The term “visualization theory” was first used by Gilbreth in May 1914, reflecting his own belief that he had finally developed a synthetic approach to the visualization and projection of production processes. He and Lillian first introduced the term “motion study” in Frank Bunker Gilbreth, *Bricklaying System* (New York: Myron C. Clark Publishing, 1909). They expanded the section of the 1909 manual into a new manual, *Motion Study: A Method for Increasing the Efficiency of the Workman* (New York: Norstrand, 1911). That same year, Taylor discussed this work in Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper, 1911). The following year, the Gilbreths published the definitive text on instruction cards and Gantt charts, Frank Bunker Gilbreth, "The Making and Use of Instruction Cards," *Industrial Engineering and the Engineering Digest* 11(May, 1912). The following year, Gantt published a more detailed discussion of the Gantt chart, Henry L. Gantt, *Work, Wages and Profits* (New York: The Engineering Magazine, 1913).

more chaotic space of the construction site²⁷⁷. For this reason, he never took spatial parameters for granted and the analysis of machine production frequently began at the collective scale, before zooming into specific operations. Furthermore, Lillian Gilbreth's training in psychology led her and her partner to consider not only how data was recorded, visualized and projected by managers, but how it was comprehended by the users of these instruments, managers and operators, substantiating Frank's multi-sensory and mixed media visualization theory, which had been initially developed in construction.²⁷⁸

Just as Taylor's work had been a refinement, as well as a critique, of systematic management, so to was the Gilbreths' work both a refinement and a critique of Taylor's work. However, due to Taylor's significant renown prior to Frank and Lillian Gilbreth's shift from the construction site to the factory around 1911, the Gilbreths' contribution has often been subsumed under that of Taylor.²⁷⁹ While Taylor had introduced Gilbreth to a wider audience through his discussion of the contractor's work in *Principles* in 1911²⁸⁰, linking him with bricklaying and motion study, it was Frank and Lillian's *Primer of Scientific*

²⁷⁷ This point is made clearly in the preface to Gilbreth's first manual, Frank Bunker Gilbreth, *Field System* (New York: The Myron C. Clark Publishing Co., 1908). I will discuss this in more detail later in the chapter.

²⁷⁸ For more on Lillian's education, see Jane Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond "Cheaper by the Dozen"* (Boston: Northeastern University Press, 2006). For more on Frank's background see Lillian Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth* (Society of Women Engineers, 1990 (1925)). and Brian Price, "Frank and Lillian Gilbreth and the Motion Study Controversy, 1907-1930," in *A Mental Revolution: Scientific Management since Taylor*, ed. Daniel Nelson (Columbus: Ohio State University, 1992).

²⁷⁹ I have already discussed one example of this occurrence in Chapter 1, where Peter Behrens discussed "Taylor's bricklaying studies". This kind of conflation would be rare in Germany, after 1920, when Hermann Muthesius first distinguished the work of Taylor and Gilbreth, as I have shown in the previous chapter, but it would continue in many other contexts.

²⁸⁰ Taylor, *The Principles of Scientific Management*, 77-103. No member of the Taylor Circle received as much praise, or as many pages, as Gilbreth. Taylor would become more critical of Gilbreth as soon as he shifted from construction to manufacturing, in 1912. After Taylor's death, in 1915, a number of more orthodox followers of Taylor's methods, including Sanford Thompson, who had developed time study with Taylor and was also an MIT-educated civil-engineer, and not a lowly brick-layer's apprentice, continued to resent Gilbreth's importance. For more on this see Daniel Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915," *The Business History Review* 48, no. 4 (Winter, 1974): 490-500. Nelson deals specifically with the issue of orthodoxy and heresy among Taylor's disciples. Even Gantt, Taylor's closest associate fell out of favor with Taylor, for similar reasons, during the same period.

Management, first published in 1912 that would be called the “clearest explanation of the system”²⁸¹. As such, a number of Gilbreth’s contemporaries and contemporary scholars have argued that he and Lillian surpassed other members of the Taylor Circle in the development of notation, visualization and projection instruments²⁸², which were the tools of most interest to architects. In Germany, where Gilbreth had consulted, between 1913 and 1915, and where he and Lillian, a fluent German speaker, had published their most extensive manual on scientific management, the *ABC’s of Scientific Management* (1917)²⁸³, “Taylor und Gilbreth” was typical in most industrial engineering journals, with Gilbreth

²⁸¹ Horace Bookwalter Drury, "Scientific Management: A History and Criticism" (Columbia University, 1915). He is discussing the second edition of Frank Bunker Gilbreth, *The Primer of Scientific Management* (New York: Norstrand, 1912). Drury explained that “(w)e have seen that the special field of Gilbreth is not the solving of engineering and other technical problems of manufacturing, nor is he interested primarily in systems of management, but his stronghold is constructive motion study.”

²⁸² In addition to Drury, a number of other scholars made the case for the Gilbreths’ unique contribution to the specific set of practices associated with scientific management. In France, Henri Le Châtelier made the point in Henri Louis Le Châtelier, "Le Système Taylor," *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* 113(March 1914). A similar argument is included in Jules Amar, *L'organisation Physiologique Du Travail* (Paris: Dunod, 1917). In the Soviet Union, Aleksei Gastev emphasized Gilbreth in Aleksei Gastev, "Organizatsiya Proizvodstva Kak Nauka," *Tsentral'nyy institut Truda* (1929). For a discussion on the direct links between Gilbreth and Gastev see Kendall E. Bailes, "Alexei Gastev and the Soviet Controversy over Taylorism, 1918-24," *Soviet Studies* XXIX, no. 3 (1977). In Germany, Gilbreth himself made the argument, in 1917, as did Hermann Muthesius, in 1920, and Martin Wagner, in 1921. The first architectural historian to discuss Gilbreth was Sigfried Giedion. Siegfried Giedion placed him as the pinnacle of a “line that leads from the fourteenth century” to the dawn of the twentieth century, following the work of Nicolas Oresme, René Descartes and Étienne-Jules Marey, as the last “master of motion studies”, and the first of the four to “capture with full precision the complicated trajectory of human movement.” To Gilbreth’s particular technique in the experimental derivation of standards, the architectural historian offered an alternative title, “space time study”. While Giedion aptly recognized the importance of Gilbreth’s “large-scale contracting engineer” experience, particularly his “study of ferro-concrete building” or his later work in industry, he focused most of his analysis on the Gilbreths’ chronographic studies of individual workers movements and their relationship to contemporary art. Giedion, *Mechanization Takes Command: A Contribution to Anonymous History*. David Nelson makes a similar argument in Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915." The most recent discussion of Gilbreth’s unique approach to construction, before he shifted to manufacture is included in Peters, *Building the Nineteenth Century*: , 93-96.

²⁸³ Frank B. Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung* (Berlin: Julius Springer, 1921 (1917)). This book and a translation of Lillian’s biography of her husband are both cited and advertised in Heinrich Nicklisch, *Wirtschaftliche Betriebslehre [Systematic Management Theory]*, 6 ed. (Stuttgart: C. E. Poeschel, 1922 (1912)). This book was also listed as the primary general manual on scientific management in Otto Rode, "Das Organisationsbureau Im Baubetrieb," *Soziale Bauwirtschaft* 4, no. 12 (15 Juni 1924). David Nelson has argued that Gilbreth was as influential in Germany as Taylor. Taylor was never discussed by German architects without Gilbreth, Gilbreth was discussed without Taylor.

alone being singled out by architects like Hermann Muthesius and Martin Wagner.²⁸⁴ In the Soviet Union, Aleksei Gastev saw Gilbreth's "building construction site" as a superior example of "the organization of production (according to the) science" of the factory, since it was a "publicly visible laboratory of organization".²⁸⁵ Even in France, where Taylor's influence crossed the Atlantic a decade before Gilbreth was discussed in *Principles*, Henri Le Châtelier's highly influential article on the "The Taylor System" was illustrated primarily with projection instruments developed by Gilbreth²⁸⁶. Nevertheless, they were examples of Taylor's "experimental method" or the laboratory method, something that Frank and Lillian also acknowledged in all of their publications.

In this chapter I will first discuss the basic instruments of experimentation and standardization, the instruction card and the Gantt chart, developed by Taylor and Gantt, comparing the earlier versions of these instruments, first published in 1903, with the more advanced versions developed by Frank and Lillian Gilbreth, in 1912. Here, I will also contrast Frank's motion aesthetic, with the more computational aesthetic of Taylor. Then I will shift to a discussion of instruments and methods developed by Frank Gilbreth for construction, between 1895 and 1906, prior to his collaboration with Lillian and

²⁸⁴ Hermann Muthesius, "Wirtschaftliche Baubetriebsformen (Systematically Managed Building Methods)," in *Kleinhaus Und Kleinsiedlung* (Munich: F. Bruckmann A.-G., 1920), 332-33. Martin Wagner, "Wirtschaftliche Betriebsführung Im Baugewerbe," [Systematic Management in the Building Trades.] *Soziale Bauwirtschaft* 1, no. 7 (1 April 1921). This text was entirely about Gilbreth, as was "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert," [How an American Contractor Promoted Systematic Management.] *Soziale Bauwirtschaft* 5, no. 3 (1 February 1925).

²⁸⁵ "Stroitel'noye delo, izdavna byvsheye sborochno-massovym, na nashikh glazakh usvaivayet moshchnyye rekonstruktivnyye tendentsii porazhayushchiye svoimi skorostyami, idushchimi za schet umen'sheniya massy i usovershenstvovaniya veshchestva, yavlyayetsya otkrytoy, Dostupnoy publichnomu obozreniyu organizatsionnoi laboratoriyey." Gastev, "Organizatsiya Proizvodstva Kak Nauka." Republished in *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda* (Moscow: TsIT, 1966), 294. Translated by me.

²⁸⁶ Châtelier included illustrations from Gantt, *Work, Wages and Profits*. and from the Gilbreths' articles on "Micro-Motion Study: A New Development M the Art of Time Study," *Industrial Engineering and the Engineering Digest* XIII, no. 1 (January, 1913). and on "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation," *Industrial Engineering and the Engineering Digest* XIII, no. 2 (February, 1913). in Châtelier, "Le Système Taylor."

association with Taylor and the Taylor Circle. While Gilbreth's work in industry was disseminated through the core publications of scientific management, these earlier principles were included in a series of articles and manuals published between 1906 and 1909 in America, and then translated, edited and condensed into a series of articles published by Martin Wagner in Germany, between 1921 and 1925. The final section of this chapter will examine the instruments and methods developed by Frank and Lillian Gilbreth for manufacture, based on their earlier training in construction and psychology, which differed significantly from the earlier instruments and methods developed by Taylor and Gantt. Although these approaches were also accessible to architects in France as early as 1914, and in Germany as early as 1917, it was not until Wagner's later articles that they would be thoroughly explained. I will conclude this section with a discussion of the Gilbreths' most sophisticated projection instruments; process charts, developed between 1913 and 1922, and first applied in American industrial management and construction management around 1926. Walter Gropius was the first architect to discuss these instruments, in 1929, after transforming and applying them to his experimental settlement in Dessau.²⁸⁷ The process chart continued to evolve during the interwar period, leading to two new instruments during the Cold War, the critical path plan in America, first used in

²⁸⁷ Walter Gropius, "Erfolge Der Baubetriebsorganisation in Amerika," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Technische Tagung in Berlin / 15 bis 17. April 1929 (April 1929). This article, based on a lecture given in Berlin on April 16, 1929 was published in tandem with "Bericht Über Die Versuchssiedlung in Dessau," *ibid.* Sonderheft Nr. 7, no. Gruppe IV NR. 4., which documented Gropius' translation of process charts used to manage New York high-rises for the design and management of his experimental settlement. A year later, the first examples of these instruments used by an American architect were published in R. H. Shreve, "The Economic Design of Office Buildings," *The Architectural Record* 67(1930).

1956²⁸⁸, and the *tsikklogram*, or “cyclograph”, first used during the same period in the Soviet Union²⁸⁹.

The Instruction Card

Frederick Taylor developed the first instruction cards during his work at Midvale Steel in the 1880s, as notes on the schedule and times of operations generated through his experiments in machine operation. Later, a stopwatch was added, constituting the first time studies.²⁹⁰ During consulting work at Bethlehem Steel, between 1898-1901, it was Henry Gantt, who developed what he would call the graphic daily balance for manufacture.²⁹¹ However, Taylor never showed interest in Gantt’s approach, and made no specific mention of it in “Shop Management”, where the instruction card was first

²⁸⁸ The critical path plan was first developed at Du Pont. For a history of that companies application of scientific management, and particularly the Gilbreths’ visualization theory, see John C. Rumm, “Scientific Management and Industrial Engineering at Dupont,” in *A Mental Revolution: Scientific Management since Taylor*, ed. David Nelson (Columbus: Ohio State University Press, 1992). For a history of the critical path plan or method, and its relation to the Gantt chart, see Walesh, *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields* 145-46. A number of practitioners and scholars have shown the Gilbreths’ process charts “anticipated the modern Critical Path Method”, as discussed in “Electronics in Military Engineering,” in *IEEE Conference Proceedings* (1964), 442.

²⁸⁹ For a discussion of the Soviet equivalent to critical path planning see Mark R. Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power* (London: Harvard University Press, 1988). Here Beissinger claims that this approach was first developed in manufacture, during the sixties, before moving to construction. He also credits Aleksei Gastev’s earlier studies and renewed interest in his work, in 1966, for these tools. Similar tools were discussed as being used in concrete panel factories in the Soviet Union, during the sixties, in E. Jay Howenstine Philip F. Patman, Charles Z. Szczepanski, Jack R. Warner, “Industrialized Building: A Comparative Analysis of European Experience,” (Washington D.C.: Department of Housing and Urban Development, 1968). I have found evidence of much earlier uses of cyclegraphs, applied to onsite construction, not factory fabrication, as early as 1949, in a series of articles and manuals developed by the Ukrainian Academy of Architecture. Their two most important publications are Aleksandr Mikhaylovich Klindukh, *Raschot Potochnogo Stroitel'stva Seriynykh Zhilykh Domov [the Calculation of the Routed Building of Serialized Housing]* (Kiev: Ukrainian SSR Publishing House of Literature on Building and Architecture, 1959). And P. N. Nedavniy M. S. Budnikov, S. A. Voronin, O. O. Litvinov, V. N. Cherebillo, Ye. G. Mel'nik, V. N. Maydanov, *Proyektirovaniye Potochnogo Zhilishchnogo Stroitel'stva* (Kiev: Gosstroy USSR Nauchno-issledovatel'skiy Institut Stroitel'nogo Proizvodstva, 1965). For a discussion of the influence of Frank Gilbreth, as well as Ernst May, on cyclegraphic projection, see Ivan Rupnik, “Building Systems/Building Territory: The Architects Role in Industrialized Housing Delivery,” in *Building Systems: Design Technology and Society* ed. Ryan E. Smith Kiel Moe (London: Routledge Press, 2012).

²⁹⁰ For an extensive account of Taylor’s work at Midvale Steel, see Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (Cambridge, MA: The MIT Press, 1997).

²⁹¹ For a detailed account of Taylor and Gantt’s work at Bethlehem Steel see Daniel Nelson, “Taylorism and the Workers at Bethlehem Steel, 1898-1901,” *The Pennsylvania Magazine of History and Biography* 101, no. 4 (1977). as well as Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*.

introduced in 1903. Gantt published his new instrument that same year, providing a much clearer explanation of its use, in conjunction with Taylor's instruction cards. Between 1895 and 1912, Gilbreth applied the laboratory method, as well as some aspects of systematic management, to his own contracting work, resulting in a book's worth of tentative standards for his organization that shared some of the characteristics of the instruction card and Gantt chart.²⁹² During this period, Gilbreth, a trained bricklayer, worked primarily in reinforced concrete, a new building system that demanded more planning and management than older construction methods, or even steel construction. His renewed interest in bricklaying, around 1907, was likely encouraged by his closer association to Frederick Taylor, and by Lillian, who saw manufacturing as a more interesting and prestigious form of production than building construction.²⁹³ Here, he began to conduct the more isolated experiments focused on individual operations, typical of Taylor's work, from which more instruction-card-like projection instruments would first appear.²⁹⁴ His and Lillian's first true instruction cards were made in 1912, when the two began consulting for the Herrmann Aukam Co. and the N. E. Butt Co., their first, and most important, American jobs.²⁹⁵ One of those instruction cards from Herrmann Aukam will serve to distinguish their approach, as well as to introduce many of the innovations that came from construction and

²⁹² Significantly fewer accounts of this period of Gilbreth's work currently exist. It is briefly discussed in Brian Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940." (Purdue University, 1987)., in Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth.* and in Peters, *Building the Nineteenth Century:* .

²⁹³ For a discussion of contact between Taylor and Gilbreth see Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency.* For a discussion of Lillian's influence on the decision to entirely focus on manufacture see Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond "Cheaper by the Dozen"*

²⁹⁴ One of his first book length publications, Frank Bunker Gilbreth, *Concrete System* (New York: The Engineer News, 1908)., was essentially a description of a tentative standard for organizing concrete construction, written for, and by, his employees. I will discuss this in more detail below.

²⁹⁵ David Nelson first researched these two installations, discussing both briefly in Nelson, "Scientific Management, Systematic Management, and Labor, 1880-1915." A more extensive discussion of these installations, building on Nelson's earlier conclusions, is included in Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940. ."

would be further developed through work conducted at those two plants and in Frank's work in Germany, for the Auergesellschaft Co. and Carl Zeiss in Germany, between 1913-15.²⁹⁶

The instruction card was the primary media of scientific management, the tangible embodiment of a standard set of methods and parameters, an organizational artifact.²⁹⁷ As Taylor explained in 1903, it was to the "art of management what the drawing is to engineering," serving as an instrument for planning and recording experiments, as well as for transferring experimentally derived standards to the everyday operations on the shop floor.²⁹⁸ Once implemented on the shop floor, it could continue to serve as a control and feedback mechanism, depending on the *spirit* of the management.²⁹⁹ Just as technical drawings varied in scale and intricacy, the instruction card could "vary in size and form, according to the amount and variety of the information which it is to convey".³⁰⁰ Additionally, its construct could range from "pencil memorandum on a small piece of

²⁹⁶ The German work is briefly discussed in "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940." I have examined the archival material documenting this work at the Gilbreth Archives at Purdue University.

²⁹⁷ The term and instrument were widely utilized, translated in French as a "Fiche de Travail" or a "Fiche de fabrication", in German as the "Anweisung Karte", or "Arbeitsplan", and in Russian and other Slavic languages, as the "tehnologii", or "tehnološka karta", a form of information technology. The term "program", as it is currently used in computer science, is also rooted in this instrument, Wiener, *The Human Use of Human Beings: Cybernetics and Society*.

²⁹⁸ "The instruction card can be put to wide and varied use. It is to the art of management what the drawing is to engineering, and, like the latter, should vary in size and form, according to the amount and variety of the information that it is to convey. In some cases it should consist of a pencil memorandum on a small piece of paper which will be sent directly to the man requiring the instructions, while in others it will be in the form of several pages of typewritten matter, properly varnished and mounted, and issued under the check or other record system, so that it can be used time after time. A description of an instruction card of this kind may be useful." Taylor, "Shop Management," 181.

²⁹⁹ In "Shop Management", Taylor made the statement that no "(n)o system of management, however good, should be applied in a wooden way." Ibid., 184. In practice, he often applied the instruction card as a control mechanism, with little interest in feedback. Others used the same instrument for control as well as feedback, with Henry Gantt and the Gilbreths making significant adjustments to the instrument so as to better serve this expanded role.

³⁰⁰ Ibid., 181.

paper”, essentially a sketch, to a “form of several pages of type written matter, properly varnished and mounted, ... so that it can be used time after time.”³⁰¹

Taylor himself first made instruction cards to record his personally funded experiments towards the development of “standard methods and appliances” at Midvale Steel during the early 1880s. These early instruction cards consisted of a list of sub-tasks, organized in a particular sequence, to which Taylor added times and other data, such as the amount of material needed. One of the first published instruction cards, included in “Shop Management”, the “Tire Turning Instruction Card”, was developed during this period at Midvale Steel.³⁰² (Fig. 05) The card included 22 sub tasks, as well as 7 lines of varying criteria, including “rate” of cutting speed, “size to be cut” and “depth to be cut”. With this particular card, Taylor, or one of his associates, could study standard parameters and then transfer these parameters to everyday shop practice. During work at Bethlehem steel, a special variety of the instruction card, a Time Study Sheet, was developed for experimental work.³⁰³ From this installation came one of the most widely published examples of an Instruction Card, the “Instruction Card Turning a Crank-Shaft, Bethlehem Steel Co. July 17, 1901”, developed by Henry L. Gantt.³⁰⁴ (Fig. 06) This standard method included 11 sub-tasks, and differed only slightly, yet significantly, from Taylor’s earlier instruction cards in that it documented both the “time this operation should take”, as well as “the time it did

³⁰¹ Ibid.

³⁰² Ibid., 86. Shop management also included illustrations of a “Time Study Notes Sheet” and “Watch Book for Time Study”, a note book with two stop watches affixed to the cover. All of these were variants of the instruction card, with the difference being that they were used primarily in experimentation, while the instruction card was used in planning and management.

³⁰³ A “Time Study Note Sheet”, also known as an Observation Sheet with the newer term becoming more widely used. For example, as seen in the 1914 G D Babcock, “Taylor System at Franklin Motors,” *The Iron Trade Review* (July 1914).

³⁰⁴ Gantt, *Work, Wages and Profits*, 264. The same instruction card, slightly modified and translated appeared in Châtelier, “Le Système Taylor,” 113. Figure 8. *Fiche de fabrication*.

take”; in this particular case it was actually two seconds faster than the standard called for.³⁰⁵ While Taylor himself discussed both the control and feedback aspects for which the instruction card could be used, he tended to emphasize the former over the latter, particularly within *Principles*. Alternatively, Gantt not only acknowledged the openness of his own experimentally derived standards, but would in fact refine the instruction card to better assist in the derivation of this feedback, and not only for penalizing the worker.³⁰⁶ Whereas Taylor only referenced relevant “blue prints” to follow, Gantt preferred including basic technical drawings as part of the instruction card. In both Taylor and Gantt’s case, the primary constituency for whom the instruction card was prepared remained a lower level member of the management, usually the foreman or the gang boss, who did not require task explanation but rather a tool for the immediate management of subordinates and the continued collection of data for the general management of a plant.

³⁰⁵ This distinction was not made in many of Taylor’s early instruction cards, which emphasized the “should” and rarely tracked the “did”. Gantt discussed the importance of feedback to the continued evolution of the tentative standard in Gantt, “A Graphic Daily Balance in Manufacture.”, in *Work, Wages and Profits*. and in *Organizing for Work* (New York: Harcourt, Brace and Howe, 1919). Horace Drury reinforced this distinction between the approach of the two men, during this period, in Drury, “Scientific Management: A History and Criticism.” Nelson has also shown how this led to Gantt’s success at Bethlehem Steel, in Nelson, “Scientific Management, Systematic Management, and Labor, 1880-1915.” Taylor’s earlier discourse did not contradict this approach, but he himself saw it as more of a matter of the manager’s discretion, and not as something that needed to be formulated.

³⁰⁶ “Acknowledging that his approach was temporary and imperfect, Gantt permitted the workers to improve the system if they could. ... For the moral effect, he allowed machinists to disregard the instruction cards and attempt to complete the assigned tasks by other methods. If they succeeded, the planning office revised the instruction cards; if they failed, they supposedly gained a new appreciation of scientific management. “The next and most obvious step,” (Gantt) added, ‘is to make it to the interest of the men to learn more than their cards can teach them.’” “Taylorism and the Workers at Bethlehem Steel, 1898-1901,” 503. Whether Gantt’s approach was actually motivated by a desire to more thoroughly exploit the workers, something that would have brought him little benefit, since he was not the owner of the plant but an external consultant, or by a genuine respect for the workers is less significant here than the fact that he formalized the collection of feedback, expanding the collection of data from experimentation to standardization, from the more controlled time studies conducted by Taylor to the application of tentative standards to the shop floor.

In addition to the application of the instruction card as an embodiment of a tentative standard, Taylor used a similar format for disseminating superstandards, standard methods, parameters and tools developed in one plant but seen as applicable to multiple plants.³⁰⁷ Upon purchase of these standard tools, the plant would also receive a “Forging Instruction Chart For Taylor Standard Straight Side Finishing Tools – Hand or Steam Hammer”. (Fig. 07) These instructions, a form of informational or organizational technology for use in manual or mechanical labor, were essentially a standard set of sub-tasks, as well as standard parameters, organized in the format of an instruction card; essentially a *software* to accompany the hardware which had been experimentally derived by Taylor.³⁰⁸ For Gantt and Gilbreth, as well as most of Taylor’s associates, the purchasing of this package was an essential part to the installation of scientific management.

The Graphic Daily Balance for Manufacture (Gantt chart)

While Taylor acknowledged the tentative nature of standards and entertained the theoretical possibility that a “workman” could discover a “new method ... markedly superior to the old”, his own particular instruments made no specific allowance for this occurrence.³⁰⁹ Furthermore, the line and bar graph visualizations Taylor used to analyze

³⁰⁷ Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*. The Taylor-White High-speed steel tools, Taylor’s most influential experimentally derived standard physical implements, which had been developed at Midvale, improved at Bethlehem, and presented in Paris, were finally perfected during Taylor’s consulting work for Tabor Tools. They were for Taylor, what the Model T would later do for Henry Ford, functioning as a proof of concept. At Tabor, Taylor also developed two other standard tools, the Taylor Universal Tool Grinder and the Taylor Flying Machine. Other members of the Taylor Circle, such as Frank Gilbreth, used both of these tools in their own consulting work. "Flga Box 11 Photographs of Various Studies 1909-1914. Folder 0031-4 - Ne Butt Co- 1913." (Fig. 08)

³⁰⁸ This chart was used by Frank Gilbreth as part of his consulting work between 1912 and 1915. "Flga, Box 44 Fatigue Study and Industrial Management, Ca. 1915-1934. Folder 0286-1 - Taylor Tools." Wiener discussed Taylor and Gilbreth’s instruction cards as an early form of software in Wiener, *The Human Use of Human Beings: Cybernetics and Society*.

³⁰⁹ “This one new method, involving that series of motions which can be made quickest and best, is then substituted in place of the ten or fifteen inferior series which were formerly in use. This best method becomes standard, and remains standard, to be taught first to the teachers (or functional foremen) and by them to

collected data from the plant were useless for tracking daily production, as they were highly abstracted and only to be viewed by the upper management.³¹⁰ (Fig. 09)

Alternatively, Gantt's methodology at Bethlehem Steel was to engage the knowledge of the employee performing the specified task, revising the experimentally derived instruction card should their approach prove more effective. As such, the instruction card placed within the shop, now executed by the employee, extended the process of standardization developed in isolated experiments under Taylor.³¹¹ Gantt supplemented Taylor's instruction cards and line graphs with an entirely new instrument, the "graphic daily balance of work", what Gilbreth would call the "gang instruction card", and now known as the Gantt chart.³¹² (Fig. 10) Whereas the instruction card focused primarily on a singular task, executed by an individual worker, the Gantt chart mapped a set of standard tasks executed throughout a given plant on a given day, week, month or even year, in one projection instrument. Here, Gantt paired an initial standard parameter, usually time, and measured it against the actual times achieved by various individuals in a plant in order to ascertain an attainable average and revise the standard. The data produced by this tool allowed a plant to analyze the "balance of work on each order" for a given day, showing what "ha[d] been done and what remain[ed] to be done, in order to ... layout the work for

every workman in the establishment until it is superseded by a quicker and better series of movements. In this simple way one element after another of the science is developed." Taylor, *The Principles of Scientific Management*, 119. This generalization was made after discussing Frank Gilbreth's work, and not his own.

³¹⁰ Taylor also retained a strict separation of the instruments used in the experimental derivation of standards, usually conducted by an individual manager and worker focused on a singular task, and the management and the analysis of the plant as a whole. These instruments were first developed by William Playfair (1759-1823), a Scottish engineer and economist. The line graph and bar chart were first used in 1786, while the pie chart and circle graph appeared in 1801. For a history of their use see Peters, *Building the Nineteenth Century*: , 291.

³¹¹ Nelson, "Taylorism and the Workers at Bethlehem Steel, 1898-1901," 502-04.

³¹² Gantt, "A Graphic Daily Balance in Manufacture." Gilbreth, "The Making and Use of Instruction Cards."

the next day in the most economical manner.”³¹³ As David Nelson has explained, Gantt “extended scientific management from the management to the workers”.³¹⁴ In addition to continuing the investigation of the tentative standard, Gantt was able to analyze the interdependency of discrete tasks in a plant, a primary use of the contemporary Gantt chart. In his 1903 article on the subject, Gantt explained that “(s)uch sheets show at a glance where delays occur and indicate what must have our attention in order to keep up the proper output.”³¹⁵ The Gantt chart allowed for the more precise identification of tasks where better organization or further mechanization would have the greatest overall effect. Unlike Taylor’s more abstract line and graph charts, “its graphical form (was) easily read”, with the “combined schedules and record(s) becom(ing) a history of how the work went through the shop and [which would] ultimately supply the information needed in modifying (future) schedules so as to get the greater harmony between the different departments and greater economy of manufacture,” enabling one to “manage a large plant as intelligently as a small one.”³¹⁶ While Gantt’s graphic daily balance was more accessible, it still extracted data from motions, projecting them into a highly abstract mathematical space, which required training to fully access. In contrast, the work of the Gilbreths tried to *appeal* to “as many senses as possible”³¹⁷, allowing for various disciplines, even various nationalities, lacking a common language to analyze a particular process through

³¹³ "The Making and Use of Instruction Cards," 421. Here, unlike in the use of the line graphs, it was possible to plan as well as analyze processes.

³¹⁴ Nelson, "Taylorism and the Workers at Bethlehem Steel, 1898-1901," 502.

³¹⁵ Gantt, "A Graphic Daily Balance in Manufacture," 423. It is this tracking of relationships that is emphasized in contemporary explanations of the Gantt chart.

³¹⁶ *Ibid.*, 431.

³¹⁷ Lillian Gilbreth, "The Psychology of Management1--Ix: Teaching, under Scientific Management," *Industrial Engineering and the Engineering Digest* XIII no. 1 (1913): 22.

visualizations that overlaid the subject being studied with the standard parameter or method being developed.

The Gilbreths' motion aesthetic

Like Frederick Winslow Taylor, Frank Bunker Gilbreth eschewed a more elite formal education in favor of an apprenticeship; the former foregoing Harvard to learn tool pattern making, the latter foregoing MIT to learn bricklaying.³¹⁸ For these two men, the purpose of their respective artisanal trades was not that of a permanent vocation, but rather a supplement to academic training within the physical space of production. During the 1880's, Taylor's considerable inherited wealth funded the development of the basic principles of scientific management.³¹⁹ Alternatively, Gilbreth's more modest background delayed his own research until the founding of Gilbreth General Contractors, in 1895. However, the subsequent success of this endeavor throughout the United States, Canada and England, would ultimately support Gilbreth Laboratories and the Gilbreths' shift entirely to consulting work for industry after 1912.³²⁰

One of the most significant differences between the two management pioneers can be detected in their aesthetic sensibilities. Taylor exhibited an early proclivity to viewing

³¹⁸ *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth*, 15-16. While Gilbreth declined a formal college education, his two sisters did not, one pursuing a course in music composition and another in botany. Both disciplines would inform Gilbreth's notational systems. Fortunately for Frank, his wife and business partner, Lillian Gilbreth pursued advanced degrees in psychology at UC Berkeley, Brown and Columbia University. For more on her education see Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond "Cheaper by the Dozen"*

³¹⁹ During work at Midvale Steel, during the 1880s, Taylor could afford to conduct his own experiments by paying the operators out of his own pocket. His own incentive wage system was a more formalized version of this arrangement. Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*.

³²⁰ Brian Price suggests that a major economic recession was decisive in Gilbreth's choice to shift to consulting in 1912. Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940. ." Jane Lancaster suggests that it was Lillian who pushed Gilbreth to shift to manufacture, something Price also agrees with. Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond "Cheaper by the Dozen"* For Gilbreth, the opportunity to continue developing his methods of planning and visualization, even at the cost of giving up a profitable business, he himself controlled, in favor of consulting work, whose profits were unpredictable, has not been adequately considered.

the world as a series of numeric outputs. On frequent travels with his family to Europe during his adolescence, Taylor would typically convert the collections of leading museums into charts based on the age or current value of the art works, a hobby he also applied to the markets of large cities.³²¹ These studies of paintings or consumer goods, like the later studies of drilling speeds or machine belt life spans, all resulted in a similar output of lists or simple line or bar graphs, more aptly described as numerical *time* studies. Gilbreth's extensive personal archive demonstrates a very different aesthetic sensibility, one that is actually best described as a motion aesthetic. Both Gilbreth's appreciation of human dexterity, a skill that the rather corpulent master mason could also personally demonstrate throughout his career³²², as well as his somewhat uncanny ability to visualize the series of human motions that had fabricated and assembled any masonry wall, whether that structure was the Parthenon, Pompeii or a brick wall behind Boston's State House, spoke to his unique aesthetic sensibility, as evidenced by this short passage:

There are two ways of piling those bricks in the kiln. The man may pile them three over three, and the brick will show the mark of the other brick. Behind the State House there is a little street where there is a wall built of bricks that have holes one and a half inches deep, due to the fact that they did not touch the fire. ... All of these variables go back to the case of what is going to happen to the bricklayer when he uses them. This looks like a simple problem, but I assure you would see where some of the things are that makes the talk about the brick. ... The Eastern bricklayer uses the trowel and puts the brick at same time. The Western bricklayer uses the "pick and dip" method. He is faster, but is not so neat as the Eastern Bricklayer. Bricklaying is very wonderful. You can see your work grow, and you can see a monument of your work... It is the work of a juggler to spread it (mortar) over several bricks, but a Western bricklayer does it regularly. An Eastern bricklayer cannot do it to the end of his days.³²³

³²¹ Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, 60-61.

³²² Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth*, 25. This skill helped him convince skilled craftsmen to try his methods during his consulting work for manufacturers.

³²³ "Flga Box 34 Industrial Management – Control and Job Classification, 1912-1921 Folder 0956 0247 - Packet Method 1915-19 the Packet System, 11.02.1914," (1914), 354. Photographs of one of Gilbreth's trips through Boston, dated June 11, 1911, when he was already beginning to pursue work as a consulting engineer are also included in the archive, Frank Gilbreth, "Untitled (Photographs of Brick Wall)," (Frank and Lillian

On his frequent walks through Boston, his travels with Lillian, and as part of his international commissions as both a contractor and a consulting engineer, Gilbreth carried a camera, documenting what most saw as static structures. (Fig. 10) Gilbreth, and later his associates, would study these images just as carefully as Taylor and his associates would scrutinize their *thousands of pages* of numeric outputs. As Lillian Gilbreth aptly explained, these visual patterns were much more democratic in their legibility than Taylor's graphs and charts.³²⁴ In addition to Lillian, whose formal education in psychology deeply influenced Gilbreth's more intuitive studies of motion, the scholarly fields of his two sisters, one a botanist, the other a musicologist, imparted a more tangibly humanistic approach. Such influences arguably helped the former bricklayer to refine his methodology and allowed the work to approach and exceed Taylor's numerical studies.³²⁵ These differences provide a useful background for the analysis of the instruments developed by that of Taylor and Gilbreth to record and disseminate the results of their experimental derivation of standards, in the more laboratory-like conditions adjacent to machine shops or construction sites, and particularly in Gilbreth's case, the spaces of production themselves.

When Frank and Lillian Gilbreth shifted their focus from construction to manufacture, around 1912, they placed focus not only on the extraction of data but the "transfer of skill", in hopes that their instruments might appeal to "as many senses as

Gilbreth Library of Management Research and Professional papers, 1845-1959, Purdue University. Box 12 Folder 0031-21 Chronocyclegraphs.1911). As the archive folder title, designated by the Gilbreths, suggests, this photo was seen as a "chronocyclegraph". Lillian and Frank's photos of the Parthenon and Pompeii are framed less analytically, but were often discussed as sharing the same logics as the more humble Boston brick walls, "Untitled (Photographs from Gilbreth Honeymoon)," (Frank and Lillian Gilbreth Library of Management Research and Professional papers, 1845-1959, Purdue University. Box 146 Folder 0028.1907).

³²⁴ Speedy was the private nickname Lillian and Frank used for Taylor, emphasizing his overemphasis on speed and his rejection of their focus on the elegance of motions. Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940.," 262.

³²⁵ Giedion, *Mechanization Takes Command: A Contribution to Anonymous History*.

possible”, both at the individual and collective scale of the plant.³²⁶ It was the Gilbreths, more than Taylor or Gantt, who would collect, systematize and disseminate the key instruments of scientific management through their publications.³²⁷ In *Primer*, the instruction card was defined as, “any method or device that will enable the management to explain to the men exactly what is wanted, ... in whatever form or physical the shape” is most suitable “for conveying the information;” for as long as the “best experience has been found, measured and recognized” it can be transmitted “from one mechanic to another without any loss in transmission.”³²⁸ In 1913, Lillian added that it should include “records made by the worker himself,” and not only those of an “inanimate foreman”, as Gilbreth had also argued, in order to form a collective “industrial memory”.³²⁹ In the definitive article on the subject, “The Making and Use of Instruction Cards”, Gilbreth explained that the “individual construction card” or the “gang instruction card”, the Gantt chart, could consist of media ranging from “directions and instructions ... written out on a piece of scrap paper or a shingle” to “sketches, drawings, two-and-three dimension photographs, moving picture films, models, object lessons, or full-sized demonstrations, as the conditions and governing features of the work will warrant.”³³⁰ Frank brought all of the representational techniques available at that time to the production of the instruction card, while Lillian’s training in psychology provided sensibility in considering each media’s legibility. Like Taylor, Gilbreth explained that a “workman (was) permitted to suggest new methods as

³²⁶ Gilbreth, “The Psychology of Management I--IX: Teaching, under Scientific Management,” 22. This text was referenced in Châtelier, “Le Système Taylor.”

³²⁷ They published the first thorough discussion of the instruction card and the Gantt chart, by 1912.

³²⁸ Gilbreth, *The Primer of Scientific Management*. Here, Gilbreth quoted from “Shop Management”. However, Taylor himself never emphasized an “explanation”, rather than measure or notation alone. The same text appears in the 1917 German translation.

³²⁹ Lillian Gilbreth, “The Psychology of Management—XI: Teaching under Scientific Management (Continued),” *Industrial Engineering and the Engineering Digest* XIII no. 2 (February 1913): 67.

³³⁰ Frank Bunker Gilbreth, “The Making and Use of Instruction Cards,” *ibid.* 11 (May, 1912): 380-81.

soon as he ha(d) proved that he understood) the standard method”. Furthermore, Gilbreth added that “any workman who can devise better methods than those that he receives from” management, would not only see his method supplant the current one, but he would be promoted to management.³³¹

The Gilbreths’ *multisensory* Instruction Card

The Gilbreths’ *multisensory* approach to the instruction cards is clearly visible in their first consulting job for the Herrmann Aukam Co., in 1912.³³² The “Instruction Card For Operation: Folding Handkerchiefs” replaced the simple list of sub tasks with two orthographic projections.³³³ (Fig. 12) The first projection was generated through the mapping of the “left” and “right hand” motions, distinguished by alternatively rendered solid, void and hatched bars drawn to scale at $1/10'' = 1/1000$ min, providing the viewer with an easily discernable rhythm of the operation.³³⁴ To the left, *micromotion studies*, photographs of the experimental derivation of the standard, complete with a custom Gilbreth stopwatch, provided further information for the viewer, and shown to the right, was “the element time per seconds”. Unlike Taylor and Sandford Thompson’s time study techniques, where the manager stopped the stopwatch at every subtask, these times were

³³¹ Ibid., 385-86.

³³² The Gilbreths consulted for Herrmann Aukam handkerchief manufacturing company, with plants in Lebanon and South River, New Jersey, between the fall of 1912 and winter of 1915, their first work for a manufacturer. This work is discussed by David Nelson (1974), Jane Lancaster (2006), and, in greatest detail, by Brian Price (1987).

³³³ "Flga Box 163 Photographs, Ca. 1912-1921 Folder 0411 1913 [Graphs with Micromotion Strips on Handkerchief Folding]." The instruction card includes graphic projection techniques from *Concrete System* (1908), *Bricklaying System* (1909), and *Motion Study* (1911). It would in turn inform a series of articles on new methods, from 1913 until 1917.

³³⁴ This was an early example of what the Gilbreths would later call a Simultaneous Cycle Motion Chart. The first article on this technique was Frank Gilbreth, "Methods of Analyzing Motions by Graphical Charts," *American Machinist* 45, no. 6 (1916). In this article, the chart is presented in isolation, but in the 1912 instruction card it was linked to a plan and a series of photographs. They are also mentioned in the 1917 German version of *Primer* and in Frank and Lillian Gilbreth, *Applied Motion Study* (New York: Sturgis & Walton, 1917).

extracted from the clock in the *micromotion* photographs.³³⁵ The second projection, drawn at the bottom of the instruction card, where Gantt would usually include a technical drawing of a component, Gilbreth included what he called a *packet plan*. The “packet plan”, or more simply a “packet”, included a standard spatial arrangement for “having pieces [tools or materials] there exactly when the man [or in this case woman] wanted them,” thereby ensuring that the “last motion of one operation has an effect on the first motion of the next operation.”³³⁶ In this particular case, the packet plan located the “folder”, the “folding board”, as well as the position of the “unfolded handkerchiefs”, in front of the folder, and the “folded handkerchiefs”, to the right, or left, depending on the folder. While the folding board itself was also a packet, as it was a simple standard tool experimentally derived through motion study by the Gilbreths at Aukam for this task, the packet plan, on the other hand, could be better described using Giedion’s account of this work, “time and space studies”.³³⁷

Experimentally derived standard packets, like the one designed for folding handkerchiefs, consisted of physical and organizational tools, and were also often developed specifically for use in the documentation and transference of skill. One of the most successful examples of such a packet was that of a modified pegboard, used at N.E. Butt Co. in 1912-13 and published in 1913 as an example of visualization, similar to his

³³⁵ “The information that was recorded in the first film taken in this lab is usable to-day in determining laws that we had no knowledge of whatever or even desire for discovering their existence at the time the picture was taken.” “Flga Box 01 Various Studies and Photo Captions 1914-1940 Folder 0019 V. I 1917-1925 Photo Caption “First Micromotion Lab Made in 1912.” The following year, Gilbreth used micromotion study material from Aukam and NE Butt Co. in “Micro-Motion Study: A New Development M the Art of Time Study.” This material would appear in Châtelier, “Le Système Taylor.” And in Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*.

³³⁶ “Flga Box 34 Industrial Management – Control and Job Classification, 1912-1921 Folder 0956 0247 - Packet Method 1915-19 ‘Packet System - 2.03.1915’.” The packet system, or packet principle, was first discussed in Gilbreth, *Bricklaying System*.

³³⁷ Giedion, *Mechanization Takes Command: A Contribution to Anonymous History*, 101.

earlier “progress photos”, that Gilbreth called “micromotion study”.³³⁸ (Fig. 13) Gilbreth inquired the most skilled workers at this plant, which assembled braiding machines, to first place the components on the pegboard, or “rigging packet”, in what they thought to be the most optimal condition, and then using a stereographic camera, documented their motions, but not their times, in using this same arrangement to assemble a braiding machine.³³⁹ From this, the most optimal arrangements and motions were chosen and named after the author, for example the “Littlefield Johnson Packet”³⁴⁰, before being presented at an “executives and workmen’s theatre for viewing and criticizing micromotion films and simultaneous motion cycle charts of best workers demonstrating the One Best Way to do work.”³⁴¹ (Fig. 14) These studies eventually evolved into the more elaborate micromotion study techniques, stereochronocyclegraphs, admired by Giedion for their formal similarity to avant-garde art, which I will discuss later in this chapter.³⁴²

The Gilbreths modified the instruction card to work with instruments and methods Frank had developed in his contracting work. The packets that were used to study the motions of skilled workers, during the experimentation process, and which were used for

³³⁸ The New England Butt Company was a manufacturer of rope and wire braiding machines, located in Providence, Rhode Island, where the Gilbreths consulted concurrently with the work at Aukam, Auer and Carl Zeiss. This packet study appeared in “Micro-Motion Study: A New Development M the Art of Time Study.” And in Châtelier, “Le Système Taylor.” And in Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*.

³³⁹ Gilbreth encouraged the skilled craftsmen at the plant to arrange the packet, holding all of the tools they would need for a particular task, as they themselves felt was most optimal, and then use this same arrangement when assembling a braiding machine, all the while documenting their motions (but not their times), using a stereographic camera and studying these arrangements and their respective motions. “Micro-Motion Study: A New Development M the Art of Time Study.” Unlike earlier physiologists, such as Edward Muybridge (1830-1904) and Étienne-Jules Marey (1830-1904), who were interested primarily in the geometry of motions of organisms, Gilbreth was actually studying the use of standard tools, workstations and factory spaces, as well as skilled craft motions, using his instruments for documentation and projection of new, more ergonomic artifacts and spatial temporal arrangements.

³⁴⁰ Ibid. Lancaster discussed this process in detail in Lancaster, *Making Time: Lillian Moller Gilbreth, a Life Beyond “Cheaper by the Dozen”* 138-44.

³⁴¹ Caption from photo “Flga Box 50 Photographs and Motion Study, Ca. 1912-1931 Folder 0299-12 Photo 610 G282.”

³⁴² Giedion, *Mechanization Takes Command: A Contribution to Anonymous History*.

the transfer of these skills, during the process of standardization, were *micro* construction plants, organizing tools, materials and products, to align with human motion in space and time. By this time, the drawings on which the packet studies were based were already known as construction plant plans.³⁴³ The micromotion studies were based on a technique Gilbreth had developed for documenting and managing the construction site, “progress photos”, or “motion pictures”³⁴⁴, which were daily photographs of construction progress, taken from a fixed position. While the temporal rhythm was increased and the size decreased, focusing on an individual operation, the micromotion study was essentially a sequence of progress photos. While Taylor’s instruction card served as a convention for the overall drawing, and the Gantt chart directly informed the simultaneous motion charts of the movement, the synthesis of these graphic instruments with the construction plant plan and the progress photos was unique; transforming the instruction card from a single linear time notation to a multi-dimensional visualization, one that had more in common with a set of architectural drawings than with a single image. At the micro scale of the experimental derivation of individual standard operations, or experimentation, the Gilbreths modified existing conventions, and at the macro scale, they replaced the Gantt chart entirely, with a

³⁴³ The term “construction plant plan” was based on the term “plant plan”, a plan of a factory that usually indicated the position of machinery. The wide use of this term in construction in the United States, around the turn of the last century, reflected the increasingly mechanized nature of building. A good survey of construction plant plans, including those prepared by Frank Gilbreth, Sanford Thompson, as well as Albert Kahn, are included in Sanford E. Thompson, *Reinforced Concrete in Factory Construction* (New York: The Atlas Portland Cement Company, 1907). A good example of a plant plan at the AEG, in Germany, around 1900, is included in Henning Rogge, “A Motor Must Look Like a Birthday Present,” in *Industriekultur: Peter Behrens and the Aeg, 1907-1914*, ed. Tilmann Beddensieg in collaboration with Henning Rogge (Cambridge: The MIT Press, 1984). A good example of a plant plan at Ford Motors, in Detroit, is included in Oscar F. Bornholt, “Eliminating Useless Trucking from the Factory: Continuous Manufacturing by Placing Machines in Sequence of Operations,” *Industrial Engineering and the Engineering Digest* XIII, no. 12 (December 1913): 507. This plan gives a valuable snapshot of the Ford facility immediately prior to the introduction of the assembly line.

³⁴⁴ The first progress photos were used to plan and manage the construction of the Augustus Lowell Laboratory of Electrical Engineering for the Massachusetts Institute of Technology, in 1901. The approach was first published in Frank Gilbreth, “Dependable Speed: The Result of the Gilbreth System and the Cost-Plus-a-Fixed-Sum Contract,” *Engineering Record* (May 12, 1906).

new set of tools and methods: the route model, the route plan, and eventually the process chart. It was this combination of micro experimentation and macro standardization instruments that would set the Gilbreths' application of the laboratory method, or as they called it the "laboratory idea", apart from the earlier work of other members of the Taylor Circle.³⁴⁵ Before discussing the route model, route plan and process chart, I will explain Frank Gilbreth's earlier work in construction, between 1895 and 1908.

Gilbreth's Field, Concrete and Bricklaying System

While Gilbreth had achieved success in his contracting business, founded in 1895 and ensuring his renown among English-speaking engineers and builders by the time he had met Taylor in 1907, it was not until Taylor's singling out of his studies in bricklaying, as the prime example of scientific management applied to production outside of the factory, that Gilbreth would reach a wider audience.³⁴⁶ European modern architects, such as Peter Behrens and Le Corbusier, first learned of Gilbreth through industrial engineering manuals

³⁴⁵ David Nelson, Brian Price and Jane Lancaster have all found that the packet approach significantly impacted the work at Aukam and NE Butt. Brian Price has critiqued what he has characterized as the Gilbreths' overemphasis on their newer visualization approaches, such as micro-motion or stereochronocyclegraphic studies, in their later publications, arguing that "these claims ignore the fact that the bench and packet system had been worked out before" these techniques were applied, and that it was these less technologically sophisticated techniques, developed through construction work, that had real impact, in terms of innovation, economy and social equilibrium in these plants. Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940.," 207-08. While the general point is valid, my own research of the Gilbreths' publications and lectures from this period suggests that they openly emphasized the importance and history of these earlier techniques. The emphasis on these more advanced instruments is more clearly attributed to later scholarship, particularly that of Siegfried Giedion. As I will demonstrate, modern architects admired the more elaborate visualization techniques but tended to also adopt the same tools that Price has identified as being used by the Gilbreths. Also, at Auer, the gas mantle manufacturer in Berlin, an installation that began in 1914, nearly two years after the first two American consulting jobs started, the instruments were used in conjunction. A detailed account of this work is documented in "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915." I will discuss the German work later in this chapter.

³⁴⁶ For example, by 1904, Gilbreth was already asked to guest lecture at MIT: "On March 28 Mr. Frank B. Gilbreth spoke upon "A Contractor's View of the Baltimore Fire." Mr. Gilbreth is one of the most prominent contracting builders of the East, and is well known at the Institute, not only as a builder of the Lowell Building and Engineering C, but also as a lecturer. Numerous slides which were procured immediately after the fire were shown." In ""Professional Societies: Civil Engineering Society, Mit", "*Technology Review (MIT)* 6(1904): 236.

and articles, published between 1911 and 1917, showing work in manufacture based on skills developed on the construction site. In 1920, Hermann Muthesius would be the first European modernist to show knowledge of Gilbreth's earlier construction manuals, most probably because of Martin Wagner, who in 1919 would be the first European modern architect to apply Gilbreth's *Bricklaying System* to settlement-building in Berlin.³⁴⁷ Wagner himself would publish the first detailed discussion of Gilbreth's approach to planning and managing the construction plant in 1921³⁴⁸, the first in a consistent stream of articles on scientific management included in two German journals, *Soziale Bauwirtschaft*, starting in March 1921, and *Wohnungswirtschaft*, starting in April 1924.³⁴⁹ (Fig. 15) Wagner provided

³⁴⁷ Martin Wagner, working at what was then the Stadtbaurat of Schöneberg, a town that would be incorporated into Berlin in 1919, oversaw the design, construction and settlement of the *Grosssiedlung Lindenhof*. This is the first documented evidence of the application of a standard method, attributable to a member of the Taylor Circle, being applied by a European modernist architect, although it does not in itself constitute scientific management but rather systematic management, as Wagner himself accurately explained in an article on the project, Martin Wagner, "Vom Eigenen Werk. (Siedlung "Lindenhof" in Beriin-Schöneberg.)," *Wohnungwirstschaft* 1, no. 1-2 (1. April 1924). The project is briefly discussed in *Martin Wagner 1885-1967: Wohnungsbau Und Weltstadtplanung*. (Berlin: Akademie der Künste, 1986). and in Manfredo Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's* (Cambridge: The MIT Press, September 1987).

³⁴⁸ Wagner, "Wirtschaftliche Betriebsführung Im Baugewerbe." This was a concise summary of Gilbreth, *Bricklaying System*. During that same year, a series of articles written by German experts from various fields on scientific management, were also included in the journal on topics, like "The Social Building Enterprises and the Technicians" and "An Assessment of the Taylor System", which included an extensive discussion of the instruction card. Between 1921 and 1925, dozens of articles on the subject were edited or written by Wagner.

³⁴⁹ Wagner's role as editor of this magazine was linked to his earlier role as the founder of the *Soziale Bauhutte*, in 1919, the *Verband sozialer Baubetriebe*, in 1920, and his directorship of the Berlin *Bauhutte*, in 1921. Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's*, 200. *Soziale Bauwirtschaft* was the official magazine of the *Bauhutte* organization, an association of cooperative building societies. This association was made possible by a law passed by the Prussian *Landtag* in March 1918, to offer low cost state loans to cooperative building societies, and also established regional and municipal agencies to supervise these agencies. Barbara Miller Lane, *Architecture and Politics in Germany, 1918-1945* (Cambridge: Harvard University Press, 1968), 88. The passage of this loan coincided with the publication of Peter Behrens' *Toward Economical Building*, to the month. *Wohnungswirtschaft* was affiliated and financed by the DEWOG (*Deutsche Wohnungsfursorge-Aktiengesellschaft fur Beamte, Angestellte und Arbeiter*), which itself received funding from the German unions.

German, and German-speaking architects, unique access to scientific management, unmatched in other parts of Europe or in American architectural journals.³⁵⁰

Sifting through the hundreds of published pages on the subject, Wagner unraveled the essential aspects of Gilbreth's approach, the packet and the progress photo, along with the various projections that linked the two. He praised the experimental nature of Gilbreth's approach, as well as his willingness to submit his "practical experience" (later *practical experiments*) in a "scientific form" to the "general public".³⁵¹ In contrast, Wagner had found that German "entrepreneurs", "feared their competition" and therefore closely "guarded their business secrets", like the "secrets of the guilds of the Middle Ages", only to provide a "few anecdotes of their experience, once they [had] retired from practice."³⁵² He also compared Gilbreth's manuals, including *Field System*, *Concrete System* and *Bricklaying System*, to professional German journals, stating that the former was "more like a textbook", while the latter resembled an "advertisement".³⁵³ For Wagner, Gilbreth's relative lack of

³⁵⁰ Hyungmin Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America* (Cambridge: The MIT Press, 2000). The first article by an American architect who had used instruments and methods attributable to scientific management in an architectural journal is Shreve, "The Economic Design of Office Buildings." Here, the approach still constituted systematic more than scientific management. One of the earliest examples of a discussion of the laboratory method is John Etanza Charles Eames, "What Is a House?," *Art and Architecture* Prefabrication (July 1944).

³⁵¹ "Ich wüßte keinen deutschen Bauunternehmer namhaft zu machen, der seine praktischen Erfahrungen in wissenschaftlicher Form der Oeffentlichkeit unterbreitet hätte." Wagner, "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert," 25. This article was a summary and translation of Gilbreth, *Concrete System*. Later that same year, Wagner would also publish his discussion of the laboratory method, which he referred to as the "practical experiment" approach, in Martin Wagner, "Rationalisierter Wohnungsbau," [Rationalized House-building.] *Soziale Bauwirtschaft* 5, no. 20 (15 October 1925). I will discuss this text in more detail in Chapter 4.

³⁵² "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert," 25. The notion of the free distribution of experience was a key aspect of Hermann Muthesius' theories of typification, something that copyright laws and rigid building regulation threatened. I have discussed this in detail in Chapter 1.

³⁵³ Ibid. Gilbreth himself would have found the term textbook or manual too rigid, presenting his earlier publications, particularly *Concrete System*, as book length tentative standards; his later publications, geared more towards industry, took the form of manuals. Nevertheless, the distinction between these publications and advertisements, German, American or French, is an important one, one that Le Corbusier did not

“complaints about ‘lazy workers’” and his inclusion of employees in the “intellectual work” of building were also noteworthy.³⁵⁴ Wagner hoped that these approaches, placed “in the hands of the cooperatively owned enterprise”, would ensure that “the Taylor-System could bring wider ranging benefits to mental and manual work” than it had in the less regulated capitalist economy in which it was developed.³⁵⁵

Like Taylor, Gantt, and Gilbreth, Wagner emphasized the organizational and iterative aspects of modern industrial production, which were not only transferable to construction but would in fact make a more significant impact than the less mechanized and less controlled space of production. For example, Gantt had explained that for a highly mechanized production space, such as a locomotive foundry, the application of systematic and scientific management was actually only a minor improvement, “because locomotives are always built according to a schedule,” the result of an “evolution of more than half a century’s work in the same line.”³⁵⁶ He claimed that scientific management, and his “graphical form”, applied by a “planning department” in the plant, could provide to a wide variety of industries, many of which lacked mechanization and/or organization, the same benefits that “time and evolution [had] done for the building of the locomotive.”³⁵⁷

Constructing a similar line of argumentation, Wagner deduced that the “installation of

adequately heed when he pushed his client and collaborator on his “laboratory” in Bordeaux, Henri Fruges, to invest in a cement gun, based primarily on the Ingersoll Rand Companies advertising brochures.

³⁵⁴ Ibid. The emphasis on the preparation of documents as a form of intellectual or mental work appears in nearly every discussion of scientific management by European modernist architects, more often than mechanization, for example.

³⁵⁵ “Dem Taylor-System in der Hand des Privatkapitals müssen wir nach wie vor den stärksten Zweifel entgegensetzen. In der Hand der Gemeinwirtschaft kann das Taylor-System aber auch den Kopf-und Handarbeitern reichen Nutzen bringen.” “Wirtschaftliche Betriebsführung Im Baugewerbe,” 84. Wagner’s own distinction between industrial organization and political economy was repeated by a number of other individuals contributing articles to the journal. The text is also similar to Muthesius’ view on scientific management, from 1920.

³⁵⁶ Gantt, “A Graphic Daily Balance in Manufacture,” 431.

³⁵⁷ Ibid. Here Gantt epitomizes the idea that modern industrial planning sought to consciously choreograph and speed up not only linear production time but that of evolution and adaptation as well.

systematic management into the factory [could] be seen as” the logical building of the established “interchangeable part production process”. However, the lack of such a foundation in the more “primitive (field of) building construction”, as well as the “constantly changing” nature of the construction site, as opposed to the “stationary operation” of the factory, would suggest that scientific management was “unsuitable” for building. Quite in contrast to this initial line of reasoning, Wagner argued that the “economic advantage of utilizing systematic management is all the greater,” when applied to an industry “riddled with outdated and uneconomical modes of organization.”³⁵⁸

Gilbreth had included a very similar argument in the preface of his first book-length publication, *Field System* (1908), when comparing the “manufacturer” and the “contractor”:

The manufacturer as a rule groups his tools, human and mechanical, at one location, possibly under one roof, in any case in one plant. His forces, under effective direction, may work as a unit; one branch of the industry is within sound of the whirl of machinery incident to the next step in the process of manufacture. Such contact makes for unity, and system may more nearly follow the points of least resistance. A contractor has no such grouping of his forces by location to aid him. One structure is erected in one state and another perhaps a thousand miles distant. The one building may be a factory, the other a city sky-scraper. Both are structures, but further than this the analogy may cease. Such conditions, peculiar as they are to the (construction) industry, must be met by completeness of organization, and by an effectiveness and comprehensiveness of systematization, which will make for results in the strenuous competition which obtains in the building trade.³⁵⁹

³⁵⁸ “Während im stationären Werkstattbetrieb die Einführung der wirtschaftlichen Betriebsführung als eine notwendige Folge des zahnartig ineinandergreifenden Produktionsprozesses betrachtet werden kann, scheint sie für den stets wechselnden, weitaus primitiver eingerichteten Baubetrieb beim ersten Blick ungeeignet zu sein. Das ist nicht der Fall. Man kann im Gegenteil sagen, daß der ökonomische Vorteil bei der Anwendung wirtschaftlicher Betriebsführung um so größer sein muß, je mehr ein Gewerbe mit rücksichtigen unökonomischen Betriebsformen durchsetzt ist. Das Stationäre eines Betriebes ist da nicht entscheidend, wenn es auch als besonders ökonomisches Moment mit spricht.” Wagner, “Wirtschaftliche Betriebsführung Im Baugewerbe,” 79.

³⁵⁹ The preface’s author is John P. Slack, who attributed this characterization to Gilbreth. Gilbreth, *Field System*, 4. The publication was presented less as a manual and more as a set of protocols extracted from the daily practice of Gilbreth’s contractors and offered to readers, a claim that can be verified by the numerous internal editions of the manual included in the Gilbreth archive, the earliest dating from 1904. “Flga Box 27 Industrial Management Folder 0926 Folder 0176 Field System 'Field System, 1904'.”

In contrast to his later work as an industrial consultant, where the derivation of new methods overshadowed immediate concerns for economy and efficiency, here Gilbreth was still the head of a large and international construction company. While his methods developed more slowly and subtly within this setting, he was able to receive the constant feedback that he, Taylor and Gantt fought so hard to gain as outsiders working in industrial plants. This publication, as well as *Concrete System* and *Bricklaying system*, was a “systematic set of memoranda”, a kind of *gang instruction card*, for managing the flow of information from the central office to the field office.³⁶⁰ (Fig. 16) The basic principles underlying both of Gilbreth’s publications were based not only on his own experiences as a bricklayer’s apprentice, but the clarification and elaboration of these principles developed through work in reinforced concrete construction. While *Concrete System* was truly a frozen tentative standard, a set of methods pulled straight from practice, *Bricklaying System*, included a more consciously edited chapter on “Motion Study”, verging on a manual. Prepared in close collaboration with Lillian and informed more directly by Taylor, it was curated with the specific intention of returning to bricklaying as a subject of study, rather than profitable enterprise, and furthermore as a way of transitioning into consulting work for industry.³⁶¹

It was through Gilbreth’s bricklaying studies that he first received international attention, with the “father of scientific management” writing that the former bricklayer had “reduced his movements from eighteen motions per brick to five” and therefore doubled

³⁶⁰ *Field System*, 06.

³⁶¹ *Motion Study: A Method for Increasing the Efficiency of the Workman*. was an expanded version of the last chapter of *Bricklaying System*, titled “Motion Study”.

the number of bricks laid.³⁶² Taylor also emphasized the “true and effective cooperation” required for bricklaying, where “several bricklayers (have to) work together in a row” so that “the walls around a building ... grow at the same rate of speed”, as opposed to the more isolated tasks that he had been studying.³⁶³ Before this publication and long after, Gilbreth would continue to reference brick fabrication and assembly, with his own skill in laying courses, the “work of a juggler”, often serving as a control group against motion studies in handkerchief folding, wire and rope braiding, carpentry and even surgery.³⁶⁴ He, and later Lillian, in her biography of her husband and partner, would continually emphasize how his training in “one of the most ancient of crafts”, as well as “construction work (in general) offered an admirable field of training.”³⁶⁵ Gilbreth even discussed his approach to bricklaying as the last possible salvation for an “art” whose “fundamental principles” were now threatened by the use of the “oldest yet newest material of construction, concrete.”³⁶⁶ In fact “concrete men” (including Gilbreth) had introduced “new ideas for finishing buildings of concrete without any brick at all”, the last area where bricklayers had enjoyed some security.³⁶⁷ If the “cost of common brickwork” could not be reduced, “bricklaying

³⁶² Taylor, *The Principles of Scientific Management*, 79. Although Taylor treated this as an elaboration of time study, choreography, rather than speed, was the real focus of Gilbreth’s work. Nelson, “Scientific Management, Systematic Management, and Labor, 1880-1915.”

³⁶³ Taylor, *The Principles of Scientific Management*, 84. Despite the glowing praise, rare for Taylor, he still described Sanford E. Thompson, the MIT trained civil engineer with whom Taylor had worked closely on concrete mixes and curing times, as being the “most experienced man in motion and time study in this country”. Thompson never actually engaged in motion study and his standards were more directly applicable to structural, chemical and structural engineering than to the planning of fabrication and assembly in time and space. Thompson’s most important manual was Frederick W. Taylor and Sanford E. Thompson, *A Treatise on Concrete, Plain and Reinforced* (New York: John Wiley & Sons, 1905). His publication, Thompson, *Reinforced Concrete in Factory Construction*., provided a survey of contemporary planning and management of industrialized construction, while Gilbreth’s *Concrete System* actually explained the process.

³⁶⁴ "Flga Box 34 Industrial Management – Control and Job Classification, 1912-1921 Folder 0956 0247 - Packet Method 1915-19 the Packet System, 11.02.1914."

³⁶⁵ Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth*, 18-19.

³⁶⁶ Gilbreth, *Bricklaying System*, 129.

³⁶⁷ Ibid.

(would) become a lost art.”³⁶⁸ This should not be done through the reduction of pay or the increase in hours, but through the increase of output, both through new devices and new methods. Gilbreth had begun work on this issue as early as 1892 and would attempt to translate his experiences in organizing reinforced concrete construction back to bricklaying by 1908, through the approach he called the packet system.

Packets

The packet system that Gilbreth had applied in the study of machine workstations at Aukam, NE Butt, Auer and Carl Zeiss was based on the act of bricklaying itself. A packet was any kind of configuration that placed “pieces (in space and in time) exactly when the man wanted them” assisting in the “continuous chain process in assembling” by ensuring that the “last motion of one operation ha[d] (the desired) effect on the first motion of the next operation.”³⁶⁹ A standard brick could be thought of as a packet, since its fabrication at a brickyard directly impacts the ease of assembly, from how it is picked up, to whether it will be used in an interior wall, where “it does not matter whether it has an upside or not”, or in an exterior wall, where laying a brick “upside down ... may get in the way of the next brick”.³⁷⁰ Differing motions, applied to the same brick, could result in “faster” brick laying but not in a “neat” wall.³⁷¹ Well before he began making photographic motion studies of bricklayers, Gilbreth began developing his first packets in the form of adjustable scaffolds. These “full sized” instruction cards, which were based on the analysis of current bricklaying techniques, were used to assist and further study those same techniques.

³⁶⁸ Ibid.

³⁶⁹ "Flga Box 34 Industrial Management – Control and Job Classification, 1912-1921 Folder 0956 0247 - Packet Method 1915-19 'Packet System - 2.03.1915'."

³⁷⁰ "Flga Box 34 Industrial Management – Control and Job Classification, 1912-1921 Folder 0956 0247 - Packet Method 1915-19 the Packet System, 11.02.1914."

³⁷¹ Ibid.

Gilbreth submitted his first patent for such a device on February 13, 1892, with the patent filed in July of the same year. (Fig. 17) The Gilbreth scaffold was adjustable in height, with “the prime feature of this invention” being the “three platforms located respectively at three different levels, the middle or stock platform being the highest, the other two platforms being arranged at opposite sides of and below the stock-platform, one for the masons and the other for the laborers, the platform for the masons being at such a level below the stock-platform that the masons may conveniently pick up the stock as necessary, while the laborers platform is arranged still lower or at such a level that a hod of stock may be dumped upon the stock platform by the laborer without dropping the stock or bending to avoid dropping it.”³⁷² After four years of use, Gilbreth further improved upon the vertical adjustment of the scaffold, adding a “lifting jack” mechanism that increased speed and safety, and also adjusted the configuration of the platforms to improve material flows parallel to and along the length of the scaffold. To further improve workflow, he developed a “standard mortar box”, as well as an optimal packet of bricks, sometimes confusingly simply called a “packet”, consisting of 20 bricks held together by wood strapping and weighing approximately 90 pounds.³⁷³

Initially, the scaffold and accessories served as the tools, as well as a kind of instruction card for use, but by the publication of *Bricklaying System* in 1909, Gilbreth had developed a new set of graphic projections to visualize, plan and manage the relationship between this early packet and the motions that it coordinated. (Fig. 18) He first compared a scaled sectional projection of a typical “trestle horse scaffold” and the bricklaying motions associated with this instrument, to the Gilbreth Scaffold, Hod Type, demonstrating

³⁷² Frank Gilbreth. Scaffold. United States, July 26, 1892.

³⁷³ Scaffold. United States, February 4, 1896.

graphically how his method “reduce[d] the number and the length of motions” and “permit[ted] all filling of each course (of bricks) to be done the entire width of the wall at once”.³⁷⁴ He then explained the Gilbreth Packet Type Scaffold through a set of drawings that included a section and plan projection of the scaffold and brick wall, the bricks numbered in the sequence of their assembly within the wall, the packets of bricks shown in their three primary configurations, as well as the location of the standard mortar boxes. This base drawing was then followed by two subsequent drawings of different configurations, the first labeled “General Arrangement of Packet Type” and the second “Location of Packs When Building Exterior Face Tier”.³⁷⁵ These drawings were further supplemented by a number of photos, which demonstrated the various conditions encountered during the use of this instrument and related methods. (Fig. 19) These photographs, mostly taken between 1908-09, had initially served as a form of *graphic daily balance*, similar to the Gantt chart, and later, as the basis of motion study from which the drawing sets were produced, similar to Gilbreth’s construction plant plans.³⁷⁶ The Gilbreths would further abstract these drawings to demonstrate the general principles of their motion study techniques in the last section of *Bricklaying System*, titled “Motion Study”, and

³⁷⁴ Gilbreth, *Bricklaying System*, 57-59.

³⁷⁵ *Ibid.*, 82-83.

³⁷⁶ Martin Wagner was the first modernist architect to use these drawings to transfer this method from Gilbreth’s work to his planning and management of the construction of the *Grossiedlung Lindenhof* in Berlin in 1919. A number of photographs of Martin Wagner’s translation of this technique are held at the *Akademie der Künste* and the *Heimatarchiv Schöneberg*, Berlin. Some of these were included in the catalogue, *Martin Wagner 1885-1967: Wohnungsbau Und Weltstadtplanung*. These drawings and photographs of their application were reproduced in Wagner, “Wirtschaftliche Betriebsführung Im Baugewerbe,” 82-83. They clearly informed the drawings used by Walter Gropius to plan the fabrication and assembly of the first phase of the *Torten Siedlung*, near Dessau, in later 1926, and their influence is also visible in Ernst May’s work in Frankfurt and especially in his proposals for an industrialized housing delivery system for Moscow in 1932. I will discuss both in Chapter 4.

in a subsequent 1911 manual devoted entirely to the subject, and projected to a broader manufacturing audience, following the publication of *Principles* that same year.³⁷⁷ (Fig. 20)

Progress Photos

As Tom Peters has pointed out, Gilbreth was the first builder to “use photography on a large scale,” from which he could both document what he called “progress photos” to inform the building process, as well as generate advertising, much like other builders at the time.³⁷⁸ The “photography system” was used to keep “office employees in touch with the conditions of the jobs” across the country. The regulations stipulated that the documentation show the men “while they are at work and not standing up, posing for a picture”, with at “least one roll of films ...taken on each job each week, and all pictures on that film should be taken on the same day.”³⁷⁹ Each roll was to have clear information as to place and date, and once exposed, was to include the contract number and date. The earliest set of “progress photos” produced in this manner, to be published, were of the “progress of work on the Augustus Lowell Laboratory of Electrical Engineering for the Massachusetts Institute of Technology”, which was built in a record two months and seventeen days, between semesters during the summer of 1902.³⁸⁰ (Fig. 21) While the majority of Gilbreth’s building work was done following drawing sets prepared by an engineer or architect, this particular commission was designed in-house, over two days,

³⁷⁷ Gilbreth, *Bricklaying System*, 152-54. *Motion Study: A Method for Increasing the Efficiency of the Workman*, 30-31. It was this series of drawings that later informed the Gilbreths’ first instruction card for handkerchief folding in 1912, which was previously discussed in this chapter. While these drawings are also based on bricklaying, they have been abstracted to serve as models for analyzing and organizing packets and motions for other labor-intensive activities. No longer projection instruments, these diagrams intend to communicate a basic set of principles. A good example of their direct application to Soviet industry during the twenties is included in Gastev, *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda*.

³⁷⁸ Peters, *Building the Nineteenth Century*: , 392.

³⁷⁹ Gilbreth, *Field System*, 37-38.

³⁸⁰ Gilbreth, "Dependable Speed: The Result of the Gilbreth System and the Cost-Plus-a-Fixed-Sum Contract." They were explained in more detail in Gilbreth, *Bricklaying System*, 22-26.

specifically to ensure rapid erection of the structure. While more conventional architectural drawings were utilized to plan and manage the process, it was developed in conjunction with progress photos, taken from a specially constructed tower next to the site and equipped with a telephone, megaphone and field glasses. During the subsequent summer, a similar technique was used for the construction of the Naval Engineering Building, also at MIT, but this time the tower was constructed even higher, for more penetrating and consistent progress photos, which were now taken every few days and served as a *graphic daily balance*.³⁸¹ Gilbreth used this method in all of his contracting work. (Fig. 22)

Sketch Models, Line Diagrams and System Charts

Starting around 1904, Gilbreth's contracting practice shifted from brick to reinforced concrete construction.³⁸² The combination of the higher precision required in preplanning and managing the erection of concrete formwork, as well as the growing distances between construction sites, field offices and Gilbreth's head office in New York City, led to him to develop his most intricate projection system to date. In addition to progress photos documenting the state of construction, the superintendent of each site would "make a sketch of model form to best suit local conditions, have model form made to

³⁸¹ *Bricklaying System*. Gilbreth included a number of other progress photo sequences in the publication. He also included his first progress photos of individual workers laying brick. Unlike the construction plant scale photos, these proto micromotion studies were not used as part of the overall project management. Wagner's studies remained primarily at this scale as well. Similar sequences were staged at the Bauhaus building and masters houses and included in Walter Gropius, *Bauhausbauten - Dessau*, vol. 12, Bauhausbücher (Munich: Albert Langen, 1930). Walter Gropius first applied progress photos to manage and document settlement-building, as well as to experimentally derive standard methods of settlement design in 1928. These are included in "Bericht Über Die Versuchssiedlung in Dessau." Ernst May used progress photos to manage and document the last phase of his experimental work at Praunheim and at Westhausen with this method between 1929-1930. Ernst May, "Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main," *Das Neue Frankfurt - Internationale Monatsschrift für die Probleme Kultureller Neugestaltung* 2/3 (February-March 1930). These studies assisted his translation of the system from the German to the Soviet contexts, where he was not able to experiment.

³⁸² Gilbreth, *The Quest of the One Best Way: A Sketch of the Life of Frank Bunker Gilbreth*.

1/8" = 1' scale" and then send the model back to the head offices.³⁸³ (Fig. 23) The model would then be used to measure development in the field, through the use of progress photos, and could also be photographed in different configurations, helping manage the process from the central office. In addition to these progress photos, a "line diagram" would be "made on tracing cloth showing the general layout of work, posts, girders, beams, panels, etc." by the superintendent.³⁸⁴ Each day, a blueprint of the line diagram was constructed, depicting the "plant and the equipment layout", as well as the position of all construction machinery, material stores and the general progress of work.³⁸⁵ These drawings would inform the planning of a day's work, with a structural bay and floor serving as a simple unit of progress. Each job also had a "system chart", a drawing that combined the conventions of a typical site plan with the basic "layout and routes of authority" between the general foreman and the various trades.³⁸⁶ With this combination of

³⁸³ Gilbreth, *Concrete System*, 12.

³⁸⁴ Ibid., 6-8. The "line diagram" was a more detailed version of a more typical "concrete plant plan", as explained in Thompson, *Reinforced Concrete in Factory Construction*. In this case, a "line diagram" was made weekly, serving as a management, as well as a planning tool, working in conjunction with the progress photos of the actual site. Gilbreth included site plan and floor plan scaled versions of the 'line diagram'. Both of the examples included here were translated and published in Wagner, "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert," 26-27. They were titled Fig. 3 "Baustelleneinrichtung für einen Eisenbetonbau der Firma Gilbreth" and Fig. 5 "Einrichtungsskizze des Bauführers für eine Baustelle." Wagner also included examples of more recent "construction plant plans" used by Turner Construction company in 1925, in "Einrichtung Der Lagerplätze," [The Laying Out of Materials Depots.] *Soziale Bauwirtschaft* 3, no. 5 (1 February 1925). Le Corbusier first made a construction plant plan in September 1926, "Flc 19835 Quartiers Moderne Fruges 758 Aménagement Provisoire De La Place 11 September 1926." He and Martin Wagner both used conventional site and floor plans prior to 1925 to plan out the construction plant. The first examples of construction plant plans used to plan and manage work are Walter Gropius' Törten Siedlung Phase 1 construction plant plan, drawn during the summer of 1926 and utilized during fall and winter of that year, and Ernst May's Praunheim Phase 3 construction plant plan, also an early route plan, prepared during the summer of 1928 and used during the fall of that year and the spring of 1929. I will discuss both in detail in Chapter 4.

³⁸⁵ Gilbreth, *Concrete System*, 12-13.

³⁸⁶ Ibid., 6-8. This projection system would also inform the diagrams that Gilbreth developed to explain Taylor's refinement of systematic management, particularly the division of labor and specialization of management positions. Gilbreth, *Applied Motion Study*, 22-23. These diagrams have often been read as the goal of scientific management, but in fact they are simply illustrations of a concept. Gilbreth's system charts and his later process charts, projection tools and not only communication diagrams, reflected the unique organizational structure of every company, even of a particular job being carried out by that company, few of

instruments, Gilbreth was able to design and manage the entire construction site as a packet, ensuring that the “planning of the methods of construction of a building (would) be laid out as carefully as the building of a great machine in a modern machine shop.”³⁸⁷ The same approach would later be used to better visualize the relationship of packet to motions in Gilbreth’s bricklaying work around 1908, inform the packets developed to assist in particular assembly tasks in manufacture, starting in 1911, and would transform into the route model and path string plan.

Visualization Theory

Between 1907, when Gilbreth first met Taylor, and 1912, when their consulting work for Aukam and NE Butt began, the Gilbreths used a series of bricklaying jobs, primarily in the Northeast, as laboratories for the experimental derivation and standardized of practices to be applied to the projection of manufacturing processes in space and time. The initial results of this research, which they would call their visualization

which matched the more idealized diagram included in the 1917 manual. For the typical reading of these charts see Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America*, 166. Analyzing only the published diagram, a form of discourse, and with no sources, primary or secondary, of its application by industrial engineers or architects, Pai concluded that “these diagrams were static models; they did not address the movement of bodies, material, and equipment in the factory. Subsequently, implementing the Gilbreth diagram into a concrete spatial, temporal, and dynamic organization required a set of institutional mechanisms that maintained its lines of control.” A similar problem of confusing a diagram for a system was brought up by Patrick Geddes, at the Town Planning in Theory and Practice conference in London in 1907; he complained that the general public, as well as professionals, had begun to equate the garden city movement with “Mr. Ebenezer Howard’s circular diagrams”, something he hoped would be fixed in the future. *Town Planning in Theory and Practice*, Town-Planning Conference (London: The Garden City Association, October 25, 1907), 23. Francesco Passanti has pointed to a similar misreading of Le Corbusier’s *Ville Contemporaine* project in Francesco Passanti, “The Skyscrapers of the Ville Contemporaine,” *Assemblage* 4(Oct. 1987).

³⁸⁷ Gilbreth, *Bricklaying System*, 19. Here, Gilbreth is discussing routing: “The routing and the consecutive order in which each wall and each structural member of the building is to be built must be diagrammed, and the dates on which the materials are to arrive on the site, and to be put in place must be agreed upon by the purchasing department and the superintendent.” For Gilbreth, the construction plant was not so different from the industrial plant, except that one was temporary and the other more permanent.

theory, would be published in 1913.³⁸⁸ Already in 1912, the Gilbreths would compliment the use of this micro approach, one that modified the instruction card and experimentation, with a macro one that would replace the gang instruction card or Gantt chart. While Taylor and Gantt had focused on scheduling in time, the Gilbreths expanded standardization to now route both in space and time. Although this approach drew more on Frank's work in reinforced concrete construction, it had been refined through installations in manufacture, at Aukam and NE Butt in America, and, starting in early 1914, at Auer in Berlin, Germany. The final and most ambitious project contributing to the development of this visualization theory, which was planned in May 1914 for the consulting work at Carl Zeiss in Jena, Germany, was cut short by World War I. Between 1912 and 1915, the Gilbreths developed a new set of macro motion study instruments including route models and route plans, which were published in a series of articles and manuals between 1913 and 1917, as well as process charts, published in 1922. These instruments, which were their most powerful time and space projection tools, were updates of the progress model, line diagram and system chart, respectively. To explain their use as a unified documentation, visualization and projection system, I will now turn to a document prepared by Gilbreth for his team in Germany, in May 1914.

The clearest and most complete summation of Gilbreth's novel approach to the design of production processes is contained on a single sheet of graph paper, conveniently

³⁸⁸ The progress photo studies of bricklaying included in the Gilbreth archive begin in early 1908 and continue until the summer of 1911. The collection of these photos is included in "Flga Box 149 Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914 Photo 622 Lohnbüro." Even after 1912, Gilbreth continued to do studies of bricklaying in America and Germany, often using this task as a way to calibrate his visualization techniques.

labeled “Visualization (Theory)”.³⁸⁹ (Fig. 24) Dated May 18, 1914, it had been prepared while negotiating what Gilbreth believed would be his most important commission, the installation of his variant of scientific management at the Carl Zeiss plant in Jena. This sheet essentially lists all of the different projection instruments that he planned to use on this job, effectively an instruction card to his staff.³⁹⁰ The first step called for acquiring a “balloon picture”, or aerial photo, of the current plant, because as Gilbreth had pointed out in a lecture, “the average plant is like Topsy”, referencing a character from Uncle Tom’s Cabin, “it just grows”³⁹¹, often without corresponding graphic documentation. Secondly, he requested a “bird-eye-view” drawing, which in the case of Carl Zeiss’s plant, already existed and was in fact a popular tourist memento for visitors to Jena.³⁹² (Fig. 25) The third step called for the construction of a “block model made to scale”³⁹³, utilizing existing plans, which would be further augmented by the “balloon picture” and “birds eye view”, as they had been for the three earlier installations. (Fig. 26) Following these more conventional architectural representations, Gilbreth added two of his own inventions to the list, the “route model” and the “path string plan”, which he also called the “routing” or “route

³⁸⁹ These sketches and hand written text are included on a single piece of hotel stationary, held in "Flga Box 133 Folder 0957-1."

³⁹⁰ The preparation of this document is indirectly discussed in the correspondence between Edgar Whitaker, an employee of the Gilbreths that had moved to Berlin in April 1914 to assist on work at Auer, and Lillian Gilbreth, who managed Gilbreth Laboratories, back in America, as well as overseeing work at NE Butt, which was still underway. "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

³⁹¹ "Flga Box 84 Industrial Management Ca. 1913-1921 Folder 0745 'Route Models Germany 1915'." Notes from a lecture given on December 12, 1915, location unknown.

³⁹² A number of these views, from 1908, 1910 and 1914 are included in "Flga Box 133 Folder 0957-1." They reveal just how fast the Zeiss plant was growing and changing during this period and how much the plant dominated the skyline of Jena, becoming a tourist attraction.

³⁹³ Most of the steps discussed here were actually taking place at Auer, but had not been as carefully preplanned as they had been at Carl Zeiss. Instead, at Auer, this visualization theory was being developed in tandem with the consulting work for that company, making this sheet a valuable reflection on that process. More specifically, a “block model” of the Auer plant had been constructed a few days prior to Gilbreth’s visit to Jena. "Box 149 Photographs, Ca. 1914 and Undated. Folder 0031-8 Germany 1914. Project 622 Photo 38." Although undated, this stereoscopic photo number indicates that it was completed in late April or early May, 1914. This is in line with the correspondence between Whitaker and Lillian Gilbreth, "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

plan”.³⁹⁴ (Fig. 27) Gilbreth later added the drawing equivalent of a route model, the “Master Process Chart”, and of the path string, the “Individual Process Chart”, articulating the more fixed schemes generated through the use of the models. (Fig. 28) The next step included conventional engineering drawings, provided by the plant, of the particular products being manufactured, including “working drawings”, “assembly drawings”, “detail drawings” and a “bill of materials”. These were then followed by more of Gilbreth’s own projection drawings, a “route chart” and a “route sheet”, which through the use of route models, path string plans and process charts, translated the more static descriptions of a plants products into a set of *time and space* parameters. Following the completion of route charts and sheets, production could commence, with daily progress being tracked and managed through a “bulletin board for sequence”, which consisted of variants of the Gantt chart, a “bulletin board for (the) office” and a “bulletin board for (the) shop”.³⁹⁵ The final step, step twelve, returned to the scale of the typical instruction card and regulated “tool standards”. With the exception of the material provided by the plant, the remaining steps all dealt primarily with the plant as a whole, and not the individual workstation, as had been the case with much of the work of Taylor and his close associates.

Just like Gantt’s graphic daily balance, Gilbreth’s *visualization theory* did not require the existence a highly specialized division of labor, the application of particular

³⁹⁴ In brief, the route model was a scale mode of the entire plant, consisting of the fundamental structural elements and floors, as well as representations of the existing machinery, locations of raw materials and finished products of any given plant. The path string plan was a model that articulated the movement of materials, products and labor configuration for a particular activity or order within a plant, using colored masonry string. I will discuss it in more detail below.

³⁹⁵ A bulletin board was a more interactive variant of the Gantt chart, one that used pins and strings to track daily progress on the shop floor. The route model was in many ways a three dimensional version of the bulletin board. Lillian explained in 1913, that unlike more rigid instruments, the “bulletin board furnishes elements of change,” explaining that “(i)n order that interest or attention be held, there must be provisions for allied subjects on which the mind is to wander.” Gilbreth, “The Psychology of Management—Xi: Teaching under Scientific Management (Continued),” 61.

compensation schemes, or even a high degree of mechanization. Rather, it was itself a distinct form of information technology, one that was even more useful when the preconditions of systematic management did not exist. The potential of consulting for Carl Zeiss excited the Gilbreths, due to the highly educated and progressive executive board, which included a physicist, a mechanical engineer and a *merchant* who were committed to research and development, with a work force consisting of highly skilled artisans who all participated in profit sharing. To address the employees' distrust of the "Taylor-System", Gilbreth drew upon his training as a master mason and his considerable manual dexterity in order to assemble one of the companies more complex optical instruments in record time. Lillian's assistance in translating the key terms of scientific management for the German audience also assisted in this process. Both saw the particular blend of science and craft, as well as cooperation and entrepreneurship of later Wilhelmine Germany, as an ideal context for developing their version of scientific management. Had it not been for the outbreak of the Great War and an increasing suspicion of foreigners, particularly those working in industry, there are clear indications that Gilbreth Laboratories would have likely transferred from Providence to Berlin. Instead Gilbreth was ultimately forced to leave Germany in the spring of 1915, prematurely concluding the advancement of his most productive endeavors.³⁹⁶

³⁹⁶ Carl Zeiss AG was founded in 1846 by Carl Zeiss, an optician in Jena, a city with a long history of glass craft. After Zeiss' death in 1889 the company was incorporated. The Executive Board at that time included Prof. Rudolf Straubel, with training in physics and mathematics, Walther Bauersfeld, a mechanical engineer, as well as a Mr. Fischer, who focused on commercial aspects and sales. Straubel and Bauersfeld would go on to construct the first modern planetarium in 1923 on the roof of the Jena plant. In 1925, Lillian would recount their German experiences: "While much behind America so far as scientific management was concerned, Germany was far in advance in some respects, such as in the economical handling of materials. The German engineers were not only clever technicians, but broadly trained scientific men... the plant where he worked ... the workers were the owners and the stockholders of the company, and living and working in the community was a liberal education in the most advanced type of sociological thought and life." Gilbreth, *The Quest of the One*

The most complete assessment of the development of the visualization theory in Germany and America is included in a typewritten transcript of a lecture, dated December 30, 1915, immediately following Gilbreth's forced expulsion from Germany and the end of his key consulting work in America.³⁹⁷ In this text, the process of generating a "master process chart" of the entire plant at a given moment in time, included three preceding steps, the "route model", the "path strings on each floor of the route model", as well as the "individual process charts", of either the different departments or different orders moving through the various departments of that plant. Here, Gilbreth foreshadowed the later goal of critical path planning, to "figure out the length of the path string", in order to identify areas where more man power, better skill, better organization or increased mechanization would have the greatest effect on the overall process. These knots in the path would also suggest where cyclographic study of individual operations should be applied. In this text the term "path string" and "cycle graph" could easily be exchanged, despite the former being made of masonry string and the latter of photons, both projected on photographic film. Within this text, Gilbreth explained the importance of the work "(o)ver in Germany", between 1914-15, where the iterative process of constructing route models had allowed for, through the use of the path string, the refined translation between route model and process chart.

The Route Model

Best Way: A Sketch of the Life of Frank Bunker Gilbreth, 61. In a letter to Whitaker on March 26, 1915, Lillian stated that "I only wish we were settled in Berlin too," and on May 21, that "I am delighted to hear from Mr. Gilbreth that you all like Germany so much." In contrast, a few years later, Henry Gantt would complain that in America "men of the "business" type of mind who have made their success through financiering, buying, selling, etc." dominated positions of power in industry, in the public and private sector. Gantt, *Organizing for Work*, 9.

³⁹⁷ "Flga Box 84 Industrial Management Ca. 1913-1921 Folder 0745 'Route Models Germany 1915'."

In the first article on the subject, published in 1913, Gilbreth presented the route model, like the high-speed steel tools or the Gantt chart, as having “been developed by (and through) the installation of Scientific Management in the different industries.”³⁹⁸ It was defined as a “method of investigating the conditions ... in any given factory as regards the passage of material through different processes.”³⁹⁹ Within the route model, the factory itself was essentially treated as a large packet, an instrument used to assist in and plan work. In the 1915 text, Gilbreth presented the route model “as a means for visualizing the problem ... of scientific management”, one that was specifically rooted in his previous work in construction. He sought to put his audience “in the frame of mind that [he and Lillian] were in at the time that [they] first undertook the problem” of visualization. For Gilbreth, the route model was developed less as a form of representation than as an instrument of projection, explaining “it is rather hard to get a definite scheme of visualizing the problem unless you have some kind of framework to work on”.⁴⁰⁰ This distinction of a *framework to work*, whether utilizing a three dimensional model or a series of two dimensional projections, is an important feature of Gilbreth’s approach, as well as that of later architectural applications, as it distinguishes the use of these instruments as diagrams or design instruments.

³⁹⁸ "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation." Material from this article, including a photograph of a route model in use, was included in Châtelier, "Le Système Taylor." Mary McLeod included this image in her article, Mary McLeod, "Architecture or Revolution': Taylorism, Technocracy, and Social Change," *Art Journal* 43, no. 2 (1983), without providing the original source or the date of its first publication in France. The 1983 caption reads “A workshop plan in relief” and explains that “(p)erspective views and models were frequently used to illustrate the production flow of multi-story workshops”. In reality, the route model was relatively rare, during the interwar period, and virtually unknown when it was first published. It was a tool of planning, not illustration.

³⁹⁹ "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation," 61.

⁴⁰⁰ "Flga Box 84 Industrial Management Ca. 1913-1921 Folder 0745 'Route Models Germany 1915'."

In order to explain the basic principles of the route model, Gilbreth repeated the descriptions of the routing process included in *Bricklaying System* and the preparation of his variants of construction plant plans included in *Concrete System*. The “first route model” had been developed “in connection with building construction” to “find out what would be the best place to leave various materials that came in and had to be deposited before being used,” a study of routes used to design a more optimal packet at the scale of an entire construction site. For Gilbreth, “(t)hese general laws”, developed in construction, often of factories themselves, could be applied “to ones of the factory”.⁴⁰¹

Tectonically as well as conceptually, Gilbreth’s models of reinforced concrete framing are a key precedent for the route model, and his discussion indicates that the specific idea came from the way in which his construction plant drawings, often affixed to drafting boards, would be stored in a “skeleton bureau” as a “series of drafting boards...held up” by posts.⁴⁰² (Fig. 29) Even these early construction plant plans differed from the conventional “drawings to scale” used by contractors and other industrial engineers, which “show[ed] the layout of the various rooms or floors in factory”.⁴⁰³ Instead, Gilbreth affixed structural plans, stripped of extraneous information, to a drawing board on to which he placed “paper or cardboard rectangles cut to scale and representing the plan area occupied by the various machines”, first on the construction plant, and later “in the room or floor under consideration” of an industrial plant, allowing for a “far more flexible fashion (of planning) than [was] possible with a drawing.”⁴⁰⁴ At first, these instruments were used independently of one another, but their eventual use “side by side”, with “each

⁴⁰¹ Ibid.

⁴⁰² Ibid.

⁴⁰³ "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation," 61.

⁴⁰⁴ Ibid.

one representing different floors of a building” proved more apt for studying the “conditions existing in two or more departments” simultaneously.⁴⁰⁵ Eventually, a typical skeleton bureau was modified so as to allow for the simultaneous analysis of multiple floors, with “the vertical scale ... exaggerated ... so we can get in here and work”.⁴⁰⁶ However, Gilbreth found this approach problematic for its lack of precise scale, explaining that “every time that you do anything with the scale you do something to your powers of visualization”.⁴⁰⁷ The “first route model was developed and built ... in the course of the installation of the Taylor System” at New England Butt Co., during the late summer and early fall of 1912.⁴⁰⁸ The model was built to a scale of 1/2 “ = 1’, as opposed to the 1/8” = 1’ scale of Gilbreth’s earlier concrete framing models. While the size of these earlier models was certainly dictated by the fact that they were often shipped across the country, the route model was intended to live and grow with its industrial plant. This particular route model, which actually consisted of numerous models of various structures, sat on a platform containing “the same outline as the lot” and pasted “outline drawings of the various factory buildings”, some modeled some not.⁴⁰⁹ Each structure was constructed of 1” thick wooden platforms, cut to the outline of the building using “outline drawings of the floors”. Depicted within the model were “(p)artitions, columns, fire walls”, as well as “(t)he position of every door and window, ... the direction which the doors swing and the space occupied by them swinging... represented by heavy black lines”. Furthermore, “all stair

⁴⁰⁵ Ibid.

⁴⁰⁶ Ibid.

⁴⁰⁷ "Flga Box 84 Industrial Management Ca. 1913-1921 Folder 0745 'Route Models Germany 1915'."

⁴⁰⁸ This model would be included as an example of this approach in Gilbreth, *Das Abc Der Wissenschaftlichen Betriebsführung*, 29.

⁴⁰⁹ "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation." In 1915 Gilbreth added that one should “(s)hape the board like the building or else you wont get the note that starts up the scheme of invention.” In either case, the model was actually of a group of factories.

openings, wells, etc.” were both indicated and “cut through the platform”. Additional emphasis was placed on the “indicating of windows” since “machines [could] be operated most advantageously when their lighting [was] considered”, while the roof, flat or sloped was not to be “represented in the model.”

Once the established structure was modeled, a series of more flexible elements were added. First, “templates of white cardboard representing the plan area occupied by each tool, or the space devoted to any single purpose in the shop” were to be made and placed in the model. Identical to the small packet plans included in Gilbreth’s instruction cards, these “templates not only show[ed] the ground space occupied by the machine”, but they documented “the space required for (an) operation”, a product of having studied the multiple positions needed to support a particular motion.⁴¹⁰ By 1914, Gilbreth added color to these templates, explaining that “you can see color before you can see shape.”⁴¹¹ Within his coding, white designated “where anything” was currently located, green for where something would be “temporarily” located, while red indicated where something would “be finally”, converting to white once it was permanently moved.⁴¹² After the “preliminary study of materials and work” and the visualization of “relative positions”, achieved through the placement of templates tacked down with pins, this instrument could now be used for “determining the best routing of work through the plant.”⁴¹³ For this purpose, “colored strings”, which indicated the “path of any material or object through” the entire plant, were

⁴¹⁰ Ibid.

⁴¹¹ "Flga Box 84 Industrial Management Ca. 1913-1921 Folder 0745 'Route Models Germany 1915'." Color also appeared in the simultaneous motion charts of the operator at this time.

⁴¹² Ibid. This approach was already used at Aukam in 1912.

⁴¹³ "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation."

added.⁴¹⁴ The color of these strings might indicate numerous processes, be it the path of a particular product being manufactured, a particular order that was to arrive and be filled at the plant, or the tracking of instruction and feedback processes of management. The production of the route model was conducted in tandem with the inventory and labeling of the plant's *physiology*, cataloging all moving objects, work stations, and, often, all windows, structural elements and circulation cores, connecting the real and the virtual spaces of the entire facility. (Fig. 30) Scaled down packets of the factory, route models, and full-scale packets of workstations were used as instruments of motion study. (Fig. 31)

The Process Chart

In his 1913 article on the route model, Gilbreth did not yet use the term “process chart”, but did discuss how “progress was charted” using the route model, with the explicit goal of “shortening the string” to accomplish a greater “economy of time and labor”.⁴¹⁵ The flexibility of the templates and strings allowed for the rapid examination of alternate layouts, some considering the movement of a particularly important machine, others an entire department. By 1914, the management of this design process provided a significant efficiency of its own, with Gilbreth claiming that the “reorganization of an entire plant”, employing a “thousand hands” had taken only four days through the assistance of the route model; a process that he estimated would have otherwise taken “a month ... by means of

⁴¹⁴ Compare to the Midvale Steel Plant Plan, 1877, the year before Taylor arrived there. “Plan of Midvale Steel Works”, in A. L. Holley and Lenox Smith, “American Iron and Steel Works,” *Engineering* (March 30, 1877): 239. Taylor and Gantt usually took the physical layout of the plant as a fixed given, while Gilbreth, an experienced factory-builder, saw it as more malleable. His new graphic instruments allowed him not only to visualize the physical structure of the plant, but also to move away from it. As Robin Evans has pointed out, “(c)ommitting to paper the mapping procedure for real things enabled the invention of others.” Robin Evans, “Architectural Projection,” in *Architecture and Its Image: Four Centuries of Architectural Representations*, ed. Eve Blau and Edward Kaufman (Montreal: Canadian Centre for Architecture, 1989), 24.

⁴¹⁵ “A New Development in Factory Study: The Use of the Route Model as a Method of Investigation.”

drawing board plans".⁴¹⁶ In other words, the development of the route model had shifted from experimentation to standardization, and was now offering certain efficiencies to Gilbreth's own *mental work*.⁴¹⁷ He would now shift to the experimental derivation of a new instrument, the process chart.

As early as 1913, additional route models were made for the *charting of progress* of particularly complex operations, such as the movement of a work order through the planning room itself. By 1914, Gilbreth would refer to these particular models as "path string models".⁴¹⁸ In his consulting work for Auer in Berlin, a significantly larger plant than either of his American clients at the time, Gilbreth developed a more direct process of translating from the three-dimensional route model of the entire plant to that of the master chart. The route model was utilized to develop a string path model of a particular process, essentially a relief model with all of the flexibility of the route model, where the results were then converted to a process chart and ultimately a master chart of the entire plant. These comprehensive drawings could not only be projected to an actual scale but could be drawn to represent the non-spatial interdependencies and hierarchies of the plant; their graphic language and syntax indexed the physical properties of the models. The process chart was not actually projecting coordinates of space or time, rather it was the result of two other processes of projection, the production of route, cycle or path drawings of motions through the entire plant, generated through the use of route and path string

⁴¹⁶ Ibid. Price and Nelson have both confirmed this in the American work. The same improvements are detectable in the use of route models at Auer. "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915." Here, Gilbreth had the opportunity to inform the planning of a new factory at the plant, as well as to define the placement of the new planning room, which would in turn house some of his staff. Route models were actually distributed, not centralized, in a number of locations throughout the plant.

⁴¹⁷ Mental work, design, planning or projecting, was the primary area where these tools were applied.

⁴¹⁸ This term was not used in the 1913 article, but it does appear on the May 1914 visualization theory sheet and in the 1915 lecture.

models, and the simultaneous production of motion charts for a particular operation, graphed on film as a micromotion study or a cyclegraph.⁴¹⁹

The first process charts, made for Herrmann Aukam and NE Butt Co., utilized route models as visualization tools, but the models did not serve directly in the production of the charts.⁴²⁰ The process charts made for Auer in Berlin, between April 1914 and May 1915, were unique in that they were a direct translation of the route models and path string charts used at that installation.⁴²¹ On March 31, 1914 Gilbreth and his associates began that installation with the construction of a block model, followed by a route model of the entire plant, the largest they had worked on thus far.⁴²² With these instruments, as well as a general mapping and inventory of the plant, Gilbreth's associates began work on a series of more detailed path string models, referred to as "detailed route models".⁴²³ As the team

⁴¹⁹ I will discuss the cyclegraph later in this chapter.

⁴²⁰ Both drew on the same graphics of his earlier "system charts" for contracting work, organizing subcontractors and the particular structures on which they worked in terms of hierarchy and interdependence. A good example of process charts from this period is the Aukam Master Process Chart made in December 1912. "Flga Box 85 Industrial Management - Planning, Ca. 1912-1925 Folder 0755-3 'Hermann Aukam Co. December 1, 1912'." This chart was neither a diagram of a predetermined system of organization to be installed in the plant, nor was it simply a reflection of the current conditions, but a step in an ongoing process. While it drew on the earlier "systems charts" from Gilbreth's contracting career, it was also significantly more complex. As Gilbreth became more comfortable with this system of visualization, he began to sketch organizations, as shown in the May 18, 1915 plan for Carl Zeiss I have discussed earlier.

⁴²¹ "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

⁴²² Letter from Whitaker to Lillian Gilbreth, April 5, 1914. Ibid. The block model photos are included in "Box 149 Photographs, Ca. 1914 and Undated. Folder 0031-8 Germany 1914. Project 622 Photo 38." The block model served as an urban scale instrument to coordinate a number of more focused route models of groups of factories. One example of these route models at Auer is "Flga Box 149 Photographs, Ca. 1914 and Undated Folder 0031-7 Germany 1914 Photo 618 G6."

⁴²³ Letter from Whitaker to Lillian Gilbreth, May 5, 1914. Discussed the cost of producing process charts and route models, and whether Gilbreth Laboratories or Auer should pay for them. In a letter from Whitaker to L. Gilbreth, dated May 18, the date of Frank's visualization theory sheet, was a list of 'detailed route models' and 'organizational (process) charts' to be made for the following departments: *Termin* Office, Invoicing Department, Statistical Department, Purchasing Department, Selling Dept. B *Inland*, Selling Dept. B *Ausland*, Selling Dept. B *Uebersee*, Central Bookkeeping Department, Registration B, Special Order Office, Auditing Dept., Shipping Dept., Advertising Dept. (where Lucian Bernhard would work in 1920), Bookkeeping B, Dept. A Selling Dept., Dept. A Shipping, Dept. A Bookkeeping, Dept. A Statistical and Dept. A Invoicing. "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

prepared these models, they simultaneously recorded their process, which would later be used by the permanent staff at Auer for the production of new routing schemes.⁴²⁴

Three of the “detailed route models”, or path string models, completed on May 22nd included a model of the routing path of a gas mantle lamp, a model of compensation as it moved through the payroll office, as well as a model of the flow of documents, particularly orders, through the accounting office.⁴²⁵ The path string model of gas mantle lamp production included a study of one of the factory spaces at the plant, as well as an adjacent storage facility.⁴²⁶ (Fig. 32) Also included was pertinent non-spatial information, such as how an order arrived at the facility, from which department, and how the order would ship, which depended on whether the customer was in Berlin, Germany or abroad. The base plan indicated the basic architectural layout of the space, positions of workstations and the shelves where the completed orders would be organized as they awaited shipping. The generation of a routing plan in this case was quite simple and as such, a photograph of the model was taken, essentially freezing this particular configuration. In tandem with the production of the string path model, Gilbreth’s associates introduced a labeling system into the lamp storeroom, linking the projection instrument and the space of production.⁴²⁷ This study would then provoke a more detailed investigation of the workstation and storage design, as well as inform the production of a master process chart, similar to the one prepared at Aukam, but now more directly informed by the detailed route models or path

⁴²⁴ Gilbreth’s team hoped to install the mental work of experimentation and standardization at Auer, leaving much of the actual physical production to the current employees.

⁴²⁵ Letter from Whitaker to L. Gilbreth, May 18, 1914, indicates that work has begun on these models, the dates on the photos indicate that they were completed four days later. "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

⁴²⁶ "Flga Box 146 Photographs, Undated Folder 0028 V. Ii 2 Bricklaying and Factory Studies 'Routing of Lamp'."

⁴²⁷ "Flga Box 149 Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914 Photo 622 03-1914."

string models. The path string plan of the *Lohnbüro*, or “payroll department”, was generated in a similar way, visualizing the complicated network of routes in a space of service production.⁴²⁸ (Fig. 33) Such complexity led to the use of colored, as well as dashed, strings rendering the various routes, which were explained with an accompanying legend. Like the lamp routing plan, this visualization included information based on the actual spatial configuration of the department, as well as non-spatial indicators at points where data entered or exited the physical space of the department. In contrast to these studies of a department’s existing configuration, studies of the accounting department depict how the path string plan was used to propose the partial reorganization of the plant.⁴²⁹ (Fig. 34) The existing accounting department was first studied using a path string model, where the nodes of the path were less specific and based on departments rather than individual workstations. This preliminary study informed the spatial and organizational “routing of the accounting department” plan, dated June 15, 1914.⁴³⁰

The studies of individual departments informed the production of a non-spatial path string model tracing the route of an order through the plant.⁴³¹ (Fig. 35) Instead of directly referencing the plant’s geography, this path string plan visualized the space of hierarchies and interdependencies between 10 distinct paths flowing through 36 departments and other significant locations in the plant. With the assistance of this model, a more permanent process chart was prepared, where the drawings’ graphic language referenced the physical

⁴²⁸ "Flga Box 149 Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914 Photo 622 Lohnbüro."

⁴²⁹ "Flga Box Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914 Photo G 622 53." "The accounting department was being physically, as well as organizationally, transformed during this period, complete with a new location and new office furniture. Stereographic photos of this space are included in the same folder.

⁴³⁰ "Flga Box 175 Blueprints, Ca. 1908-1937 Folder 0695-1 1914 Germany Drawing Wegezeiger Rehnungs Bu.." "Here, a more conventional architectural plan was generated through the use of Gilbreth’s more advanced visualization and projection tools.

⁴³¹ "Flga Box 149 Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914 Photo 622 62."

properties of the strings used in the model.⁴³² Although it shared a graphic language with Gilbreth's earlier process charts and system charts, the process of generation was far more iterative and empirical at Auer, due at least in part to the "favorable attitude toward the (scientific management) movement and willing spirit of cooperation" at that plant.⁴³³ By the end of the work in Germany, the process chart had replaced the instruction card in many areas of work.⁴³⁴ Between 1915 and 1921, the Gilbreths would further refine the explanation of their new instrument, before publishing an article on the subject in 1922.

Although the process at Auer was discussed in his 1915 lecture, it would not be emphasized in his 1922 article, "Process Charts and Their Place in Management".⁴³⁵ It was specifically this iterative process that kept the instrument experimental and projective, rather than purely deductive and representational. This important relationship between the subject of analysis and the tool of analysis and projection, much like the distinction between experimentally deriving or simply applying standard tools, parameters and

⁴³² "Flga Box 177 Blueprints, Ca. 1912-1925 Folder 0760-2 1912-1925 Drawing Untitled." In conjunction with these charts, a series of standard instruments were developed, including office desks and mail inboxes, based on Gilbreth's earlier mortar trays for bricklaying and stamps. These are included in "Flga Box 149 Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914."

⁴³³ Letter from Whitaker to Lillian April 5, 1914. By July 1914, complaints from the existing management as to a "lack of hearty co-operation" led to a series of lectures and seminars explaining every aspect of the laboratory method in detail, which led to better relations by the end of that month. On July 27, "work (was again) proceeding quite harmoniously, better than for some time". In December 1914, Whitaker was critical of their own work, explaining that he was "very much disappointed with the condition of our Chart department" and that "(t)here seems to be a lack of definite, exact understanding as to what each chart should show, and how to obtain the necessary data for it." This led Gilbreth to recommend training assistants for this work, from the Auer workforce, a process that began in January 1915, with positive results by February 26, 1915, when these Auer employees began presenting to their colleagues, in German. By March 11, Whitaker reported that, "work is proceeding nicely here," with all indications that it would have continued to do so, if the worsening conditions brought on by World War I had not led to a premature termination of the contract on June 1, 1915. "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

⁴³⁴ Letter from Whitaker to Lillian, January 13, 1915.

⁴³⁵ The paper was first presented in December 1921, at the annual meeting of the American Society of Mechanical Engineers. Its original title was "Process Charts: First Steps in Finding the One Best Way to do Work", with the original version published in March 1922, as part of the meeting's proceedings. The slightly shortened more widely disseminated version of the lecture was, Frank and Lillian Gilbreth, "Process Charts and Their Place in Management," *Mechanical Engineering* 44(1922).

methods, is crucial to the understanding of architects' later application of this instrument. In conjunction with the route and path string model, the process chart was a useful instrument of clarification and focus. In 1915 the process chart was explained as a visualization instrument used to "show several different pieces (moving), on the same chart" as "just one thing", as a single visualization, in conjunction with the route model, the instrument of conjecture and projection.⁴³⁶ By 1921, while presenting their new "method of pointing out weaknesses in methods of manufacture", the Gilbreths exhibited many of the same tendencies as Taylor, eliminating any reference to the more messy use of the route model that had been crucial to the success of their own work between 1912 and 1915. Now, the process chart was simply defined as a "device for visualizing a process as a means of improving it", a "record of present conditions" which presented "data" in a "simple, easily understood, compact form", a definition which neither prevented nor encouraged the use of the route model.⁴³⁷ Lillian's interest and training in psychology is evident within her assertion that the process chart "prevent(ed) 'inventing downward'", "stimulat(ed) invention that is cumulative and of permanent value" and was "not only the first step in visualizing the *one best way to do work*" but also "useful in every stage of deriving it".⁴³⁸ The

⁴³⁶ In his December 30, 1915 lecture, from where this quote is taken and the first recorded public mention of the process chart, he explained the sequence of work, starting with the "route model", followed by the "path strings on each floor of the route model", followed by individual "process charts", like the one following an order through Auer, followed by a master, or "one process chart", visualizing the current organization of the company itself, similar to the earlier charts already in use at Aukam in December 1912. "Flga Box 84 Industrial Management Ca. 1913-1921 Folder 0745 'Route Models Germany 1915'." No specific mention of route models would be made in the 1921 and 1922 articles.

⁴³⁷ F B Gilbreth, "Process Charts: First Steps in Finding the One Best Way to Do Work (Lecture, December 1921)," *The American Society of Mechanical Engineers* (March 1, 1922): 3-4.

⁴³⁸ *Ibid.*, 4. This was a thinly veiled jab at Taylor, now deceased, and his more orthodox associates, who had become increasingly hostile to the Gilbreths' brand of scientific management. The term "one best way to do work" was the ideal standard towards which the tentative standard evolved and adapted through the process of experimentation and standardization. The contemporary term "best practice" is a variant of this earlier term. The Gilbreths removed this term from the title and this passage in the edited version of this text, Gilbreth, "Process Charts and Their Place in Management."

Gilbreths argued that the approach could be applied to the “routine of production, selling, accounting and finance.”⁴³⁹ Through the use of a common set of visualization techniques, “similarities in different kinds of work” could be identified, further assisting the Gilbreths’ earlier goal in seeking the “transfer of skill” beyond the boundaries of a particular plant or discipline.⁴⁴⁰ Quite in contrast to the usual emphasis on specialization, the Gilbreths saw their visualization theory as a means of presenting “information regarding existing and proposed processes in such simple form that such information can become available to and usable by the greatest possible number of people,” incorporating the “special knowledge and suggestions” of those individuals “in positions of minor importance.”⁴⁴¹ Such visualizations eliminated the need for “translating” between disciplines and acknowledged that the “time ha(d) passed – if it ever existed – when the engineer prided himself upon the abstruse material that he studied and presented.”⁴⁴² This new approach, which “show(ed) the planned process as well as the present process”, served as a common international and interdisciplinary visual language, which could now address a mass audience already in possession of a variety of skills and experiences.⁴⁴³ While the new *route man* should have some “engineering training and experience”, he no longer needed to be an expert on the

⁴³⁹ Actual examples of process charts, applied to two other fields, the military and the domestic realm, were also included in the article. Assisting the American war effort against the now inhospitable Germany, the Gilbreths had applied their motion study approach to the rehabilitation of maimed soldiers, as well as to the more efficient “loading of rifle grenades”. Additionally they had begun to use their own home and large family to conduct motion study experiments in the organization of domestic life. One such “packet” of a children’s bedroom considered how its spatial configuration and sequence of occupation could assist in “fatigue elimination in hair combing”. Gilbreth, “Process Charts: First Steps in Finding the One Best Way to Do Work (Lecture, December 1921),” 12-13, 18. The same examples were included in the *Mechanical Engineering* article.

⁴⁴⁰ *Ibid.*, 4. Also in *Mechanical Engineering*, 38.

⁴⁴¹ *Ibid.*, 5. *Ibid.*

⁴⁴² *Ibid.* *Ibid.*

⁴⁴³ *Ibid.* *Ibid.*

“actual details of the processes” being routed.⁴⁴⁴ Experience in the process of visualization and projection itself generated an “unbiased eye” unburdened by “habit, worship of tradition and prejudice”, having “ a new view point concerning old traditions”.⁴⁴⁵ The complexity of contemporary industry, no longer defined solely by an understanding of *materials and the forces of nature*, needed a common visual language in order to facilitate cooperation; this was the Gilbreths’ ultimate goal.

Like the late publications of Taylor, here the Gilbreths’ explanation of the actual “mechanism of making process charts” lacked the previous detail and synthesis of their earlier publications.⁴⁴⁶ Alternatively, a great deal of attention was given to “therbligs”, a set of symbols based on botanical notation developed by Gilbreth in order to visually code the various nodes of the process chart.⁴⁴⁷ (Fig. 36) Along with the lines representing the paths of a particular route, these symbols added standard information regarding the general character of the node. For example, a diamond shaped node indicated that a particular

⁴⁴⁴ Ibid., 6. Route men at the Auer installation were promoted from the existing workforce.

⁴⁴⁵ Ibid. This new vision is nearly identical with the theories put forward by Le Corbusier in Le Corbusier, "Des Yeux Qui Ne Violent Pas... Iii: Les Autos," *L'Esprit Nouveau* 10(1920). and later by Laszlo Moholy-Nagy. Nagy would eventually write about the Gilbreths, in Laszlo Moholy-Nagy, *Vision in Motion* (Chicago: Farnham, 1947). In all three cases, it was not simply a new theoretical or mechanical lens that provided this new vision, but a process of translation, from idea to drawing, from drawing to building, and from building to spatial and temporal experience, as well as an observation of use of the various artifacts that one used to manage the various translations, drawings, tools of fabrication and *tools for dwelling*.

⁴⁴⁶ For example, *Concrete System* and *Bricklaying System* included a more theoretical discourse overlaid, not only on a more practical explanation of the various systems, but the actual system itself, while *Motion Study* (1911), and especially *Applied Motion Study* (1917), are more manual-like. The same trend can be seen in the route model and process chart, starting with a more raw discussion in the 1913 articles in *Industrial Engineering* magazine, the more direct discussion in the 1915 lecture, and as contrasted with the later articles, in 1922. However, as Lillian herself often accurately pointed out, it was really the process of notation, visualization and projection, using their visualization theory, that transferred skill, with the written page being a poor surrogate, only appealing to one sense.

⁴⁴⁷ Therbligs first appear on the May 18, 1914 visualization theory sheet. Botany was on Gilbreth’s mind at that time, since he had spent a few days photographing the motions of flowers in bloom at Dresden botanical garden, for his sister, before traveling to Jena. While useful, they certainly did not have the same impact as the route model or the path string plan, and yet it is precisely these symbols that would later become the most recognizable aspect of the Gilbreths’ visualization theory. For example, it was the therbligs that are mentioned when attributing critical path planning to the couple, "Electronics in Military Engineering." They did not seem to have any direct impact on architectural practice.

object would have an “inspection for quality”, whereas additional symbols denoted whether that inspection was conducted through “seeing”, “smelling”, “hearing”, “tasting”, “feeling” or “kinesthesia”, an “awareness of the position and the movement of the parts of the body”.⁴⁴⁸ Circular symbols related to types of motions, while triangular symbols relayed information about storage.

The “collecting and using data”, or experimentation, used to inform the initial process charts was described as being conducted through the use of instruction cards, since there was “no process that warrants a process chart that does not warrant a ‘write up’ or ‘written system’”.⁴⁴⁹ The instruction cards themselves were to be used in conjunction with “micromotion studies”, from which individual process charts of “each and all of the cycles in any given operation” could be made, “even if such motions charts [were] made roughly,” much like many of Gilbreth’s freehand sketches of these studies.⁴⁵⁰ The Gilbreths included a “process chart for ordering blank forms” as an example of how their process chart system could also replace the existing instruction card medium.⁴⁵¹ (Fig. 37) The conduction of “micromotion studies” could be done of both “existing and proposed processes” and could

⁴⁴⁸ Gilbreth, "Process Charts: First Steps in Finding the One Best Way to Do Work (Lecture, December 1921)," 8. *Mechanical Engineering*, 39.

⁴⁴⁹ Ibid. Here, the Gilbreths used an instruction card from Frank’s contracting business in 1899 as an example. The desire to make this new *software* compatible to existing operating systems may explain why they chose such an outdated form of information technology. In addition to instruction cards generated in the plant, Gilbreth also discussed the use of “national standards”, a specific reference to “the remarkable attempts of Germany and Holland” in their development of the DIN-Norms, as a basis for the production of process charts for a particular plant. I will discuss this program in more detail in Chapter 4.

⁴⁵⁰ Ibid., 15. Some of these sketches were included on the visualization theory sheet from Jena.

⁴⁵¹ Ibid. During the twenties, the Gilbreths specialized in preparing these kinds of visualizations for industries. While the published example included 12 tasks, a process chart for entire cotton mill included 46 tasks, and was nearly 6 feet in length. "Flga Box 85 Industrial Management – Planning, Ca. 1912-1925 Folder 0755-3 Drawing 'Cotton Mill - First Rough Draft'." (Fig. 38) Du Pont’s Engineering Control Group developed the critical path method to plan and manage a chemical plant in Louisville, Kentucky that included 800 individual tasks in 1956. This led them to engage the Remington Rand Corporation to assist them in this process through the use of their UNIVAC computer in 1957, digitizing the critical path method. Welsh, *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields* 145.

be even more precisely analyzed and visualized through the “chronocyclegraphic process”, a variant of micromotion study that generated process chart like drawings automatically. While I have found no evidence of the application of this technique to architectural work, these studies, which were widely disseminated in the popular press in the United States and Europe during the interwar period, were certainly inspirational to modern architects.⁴⁵²

The Chronocyclegraphic Process

The chronocyclegraphic process was the one approach used in Gilbreth’s installation work between 1912-1915 that was the most distinct from that of his earlier construction work.⁴⁵³ Gilbreth developed this process in 1912 while at Aukam and NE Butt.⁴⁵⁴ In March 1913, he filed for a patent, which received approval that same October.⁴⁵⁵

(Fig. 39) The construction of micromotion studies involved the sequential photography of a

⁴⁵² Brian Price has questioned whether these studies had any direct impact on the work of the Gilbreths, implying that they were used more as advertising. Price, "One Best Way: Frank and Lillian Gilbreth's Transformation of Scientific Management, 1885-1940. ." Giedion, on the other hand, gave these studies primacy over all of the other work of the Gilbreths, arguing that these images influenced avant-garde art, which in turn influenced modern architecture. Giedion, *Mechanization Takes Command: A Contribution to Anonymous History*. In reality, both have isolated these studies from the Gilbreths’ broader visualization theory. While the studies were probably overkill, with micro motion studies already able to facilitate most of what cyclegraphs could do, this technique did prove to be useful in the field in which it originated, physiology. For example, Nikolai Bernstein, a Russian physiologist who had worked at Aleksei Gastev’s Center for Labor, and survivor of the Stalinist purge, brought these techniques back into this field, without adequately crediting Gilbreth, and making no mention of his murdered former boss, in Nikolai Bernstein, *The Co-Ordination and Regulation of Movements* (Oxford: Pergamon Press, 1967). Cyclegraphs were also the first time the Gilbreths projected a sequence of movements in elevation and section, not only in plan.

⁴⁵³ While clearly informed by micromotion studies, which were a combination of Gilbreth’s progress photos, Taylor and Thompsons’ time studies, as well as the earlier physiographic studies of Étienne-Jules Marey and Eadweard James Muybridge, they exhibited a number of unique traits from this previous work. The most extensive discussion of this approach is included in Giedion, *Mechanization Takes Command: A Contribution to Anonymous History*. Price also discussed it briefly in Price, "Frank and Lillian Gilbreth and the Motion Study Controversy, 1907-1930." The first publication of a cyclegraph in an architectural journal is probably Charles Eames, "What Is a House?."

⁴⁵⁴ Price and Lancaster both discuss this early work at Aukam and NE Butt.

⁴⁵⁵ F. B. Gilbreth. Method and Apparatus for the Study and Correction of Motions. United States, Oct. 3, 1916 (Filed May 23, 1913). First presented publicly in early 1916, F. B. Gilbreth and L. M. Gilbreth, "Chronocyclegraph Motion Devices for Measuring Achievement" (paper presented at the Second Pan-American Congress, Washington D.C., January 3, 1916). This article was reproduced in Gilbreth, *Applied Motion Study*, 73-96.

particular motion, usually instructed by a packet designed by Gilbreth, using a custom stopwatch and gridded background for temporal and spatial scale. Alternatively, the chronographic process replaced the stopwatch with incandescent lamps, worn by the operator, and wired to a tuning fork interrupter that broke the electrical current at a consistent rate. The operator was then photographed using a long exposure, generating a dashed line that traced the various motions of the body at work. In the patent, Gilbreth described a motion study laboratory space, complete with gridded surfaces intended to further assist in the study of motion following the experiment's conclusion. With each incandescent light attached to a different tuning fork, a variety of line types distinguishing these paths could be generated, aiding not only in the measurement of a particular portion of a motion in space and time, but simultaneously visualizing its overall elegance. This information would then be translated into a correlated motion chart, which was identical to those used in micromotion study and utilized a graphic language analogous to process charts.

A good example of the use of the chronocyclegraphic process is found in Gilbreth's last months of consulting for Auer in Berlin. (Fig. 40) From February until June 1915, Gilbreth and his associates studied that plant's box factory, where the shipping containers for the company's main product, the gas lamp, were produced.⁴⁵⁶ Gilbreth approached the problem using his packet principle, even borrowing initial data from his bricklaying studies.⁴⁵⁷ A route model of the entire plant suggested that a more efficient routing of production, use and storage of these boxes would have a significant impact in overall

⁴⁵⁶ The factory produced the packaging for the lamps. "Flga Box 133 Industrial Management, Ca. 1908-1922 Folder: 0956-2 1914 1915."

⁴⁵⁷ He was also continuing to conduct micro motion and chronocyclegraphic studies of bricklaying in Berlin. Ibid.

operations. During the spring of 1915, a series of studies investigating the stacking of standard Auer boxes were conducted in a provisional motion study room using the chronocyclegraphic process.⁴⁵⁸ All of them were made for stereoscopic viewing but without the use of a tuning fork. The first set of photographs, 622 184, resemble those of motion study, the operator and the stack of boxes are still visible and only one cycle of the operators left and right hands are visible. However, in a subsequent photo, 622 185, there are two full cycles of lifting a box visible and the rest of the background is darkened. Here, the difference between the first, choppy, cycle and second, smoother, cycle is already visible. In the final study, the moving operator and objects have entirely disappeared, instead replaced by a set of graphs charting the simultaneous chronological cycles of motions of both operators' arms as they stack two rows of boxes. The process of stacking these boxes, similar to and informed by Gilbreth's bricklaying studies, was distinct from many of the repetitive processes studies of the machine shop in that the study also began to map the emergence of an aggregated structure. Like the earlier chronographic studies in America, this work had a minor impact on the economy and efficiency of Auer's operations when compared to the use of other instruments, such as the route chart or the new packets themselves. Such a level of precision was simply not necessary in construction or even most manufacturing processes at this time. Rather, the development of these tools was driven more so by an open ended interest in the future of visualization, as well as demonstrating the superiority of motions, at the scale of the plant or the workstation, that had been projected using other tools.⁴⁵⁹

⁴⁵⁸ "Flga Box 146 Photographs, Undated Folder 0021 Unidentified People Gathered around a Table."

⁴⁵⁹ There are also clear relationships between the development of string path studies of the plant and cyclegraphic studies of the workstation, although the "space and time studies" of the former seem to have

Dissemination of the Gilbreth's visualization theory, 1909-1930

I have identified four general periods of dissemination of the Gilbreths' evolving visualization and projection approaches. The first period follows the publication of Frank's first articles and manuals, primarily related to construction, between 1906-1911, where familiarity with this material was limited primarily to American engineers.

The second period follows the attention given to Gilbreth's work by Taylor in 1911, and the inclusion of his new instruments developed in industry, which were included in more general publications on scientific management, between 1914 and 1917, after which a familiarity with this material expanded to Europe. The third period follows the particular emphasis placed on Gilbreth's work by Hermann Muthesius and by Martin Wagner, between 1920 and 1925, through which primarily German-speaking architects gained greater familiarity with this material. The fourth and final period, following Gilbreth's death in 1924, was marked by the broader application and translation of the process chart to industrial and construction management, first in the United States, but also in Western Europe and in the Soviet Union.⁴⁶⁰

In terms of settlement-building, the first potential application of the laboratory method theory or the specific visualization approaches of the Gilbreths is Grosvenor Atterbury's work for the Russell Sage Foundation, in New York City starting in 1908. A more thorough application is visible in the work of two American engineers, George Harms and Henry Small, working in collaboration with two Dutch architects, Hendrik Berlage and

preceded those of the latter. Due to the horizontal nature of many industrial plants, the three and four dimensional path string models tended to result in plan projections in Gilbreth's own work while the studies of the work station tended to produce projections more similar to a section or elevation projection.

⁴⁶⁰ Mauro F. Guillen, *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture* (Princeton: Princeton University Press, 2006). I began with Guillen's broader historiography, examining the dissemination and actual use of these instruments to confirm the application, and not only the discussion of scientific management.

H. Hanna on a house in Santpoort, Holland, in 1912; these two engineers would apply these principles to the settlement scale through a series of projects in France, between 1914 and 1918. John Conzelman, an American engineer, collaborating with the architectural and town planning firm, Herding and Boyd, was the first to apply these principles more fully to settlement-building in Youngstown, Ohio, between 1917-1919, following a system of fabrication and construction already developed for infrastructure and factory-building. While in 1918 Peter Behrens would be the first architect to claim to have applied Gilbreth's work on bricklaying to his own settlement design system, Martin Wagner would actually be the first architect to apply Gilbreth's Bricklaying System to settlement-building, in Berlin, between 1918-19. Le Corbusier was the first architect with knowledge of Gilbreth's visualization instruments, which he had seen possibly as early as 1914, and certainly by 1917, to modify the more conventional instruments of architectural projection to assist in his own "laboratory" in Bordeaux, between 1923 and 1926. Martin Wagner was the first architect to utilize many of Gilbreth's visualization instruments to assist in his "practical experiment" in Berlin, between 1924 and 1931. Walter Gropius and Ernst May were the first modern architects to develop new visualization instruments through work on their "experimental settlements" in Dessau and Frankfurt, between 1926 and 1930. May would take these instruments to the Soviet Union in 1930, where they would later inform that country's massive postwar industrialized housing delivery system.⁴⁶¹ That same year, R. H.

⁴⁶¹ One of the most advanced projection instruments of this type, specifically intended for use in "settlement-building", was developed by the Ukrainian Academy of Architecture and Construction between 1948 and 1959. That approach, called *potochnoye stroitel'stvo poselkov* or "routed settlement-building", projected the "individual routes" of an "overall task", "graphically", with "x-axis including time (shifts, days)" and the "y-axis including the scope of work (in tasks), work stations, structures" generating a series of "broken lines reflecting the scheduling and routing" of a particular "cycle". This particular instrument was aptly named a *tsiklogramm*, or "cyclegraph", and was first used by the Ukrainian Academy in 1949, the former term had

Shreve published an article discussing his firm's work on the Empire State Building, which included the use of progress photos, route plans and process charts, one of the first examples of the use of these theories and tools by an architect in America.⁴⁶²

Conclusion

Between 1880 and 1903, Frederick Taylor developed the laboratory method, primarily through work in two machine shops, Midvale Steel and Bethlehem Steel. There he focused primarily on experimentation, developing the instruction card to plan, record and disseminate his experimentally derived tentative standards. In direct collaboration with Sanford Thompson, he also developed a particular method of experimental derivation of standards, time study, an approach that was successfully applied to the *engineering of materials and forces of nature*, particularly as related to steel tools and concrete mixes, and less so to the *engineering of men and capital*. It was Henry Gantt, working in tandem with Taylor at Bethlehem Steel, but motivated by his own interpretation of Taylor's theories, that developed the first instrument and method of standardization, the graphic daily balance for manufacture (1903), also called the gang instruction card (1912) or the Gantt chart (1922). Gantt's approach traded some of the control of Taylor's earlier methods for a greater degree of feedback, therefore expanding the derivation of standards from the more laboratory-like environment set aside within the industrial plant to the social space of the plant itself. As his first publication emphasized, Frank Gilbreth approached the work of the manufacturer through his work as a contractor, a unique perspective within the Taylor

been used in the Soviet Union since the mid twenties, originating with Aleksei Gastev, as the Slavicized version of Gilbreth's term cyclegraph. I will discuss this tool in the Conclusion.

⁴⁶² Process charts were used for the planning and management of the construction of the Greybar Building in New York, in 1926. Gropius, "Erfolge Der Baubetriebsorganisation in Amerika." Process charts as well as progress photos were also used in the planning and management of the construction and use of the Empire State Building in 1930. Shreve, "The Economic Design of Office Buildings."

Circle. Like Taylor, whose initial experiences as a steel-tool makers apprentice would inform his emphasis on the isolated workstation, Gilbreth's techniques initially reflected his own training as a bricklayer, as seen in his first *packet*, the adjustable scaffold he patented in 1895. Gilbreth's experiences as a contractor who managed multiple temporary spaces of production, between 1895 and 1912, shifted his focus from the scale of an individual workstation, a scaffold or a machine tool, to that of the construction plant, the industrial plant, and beyond, to the more territorial scale at which systematic management or systems thinking had first been developed to address.⁴⁶³ When he and Lillian shifted their attentions from the construction plant to the industrial plant, in 1912, they applied this unique experience to the experimental derivation of standard methods at the scale of the single workstation, treating it as a miniature construction plant, and to the gradual standardization of the industrial plant as a whole, building upon and even supplanting Gantt's earlier graphic methods. As early as the scaffold patent of 1895, Gilbreth was essentially designing a temporary architectural artifact, one that accommodated a particular user, the skilled bricklayer and his unskilled assistants. As a contractor, Gilbreth treated his construction plant plans the same way, designing them around a particular user group, his employees, while at the same time following the parameters defined by other engineers or architects for a more permanent constituency, whether it be MIT faculty, industrial workers or clerks. During his consulting work for industry, between 1912-15,

⁴⁶³ Systematic management had first been developed to manage the production and operation of transcontinental railways in America, around 1850, before being translated for the factory, around 1880. Scientific management moved out of the factory around 1900, through the work of Taylor and Thompson, on concrete mixes and curing times, and through the work of Gilbreth on spatial and temporal planning of construction. Gilbreth brought these techniques back into the factory, around 1912. Around that time, a few American engineers began to apply these principles to industrialized settlement-building, in America and Europe, before European modernist architects began to adapt these tools to settlement design, starting in 1918.

Gilbreth was finally able to apply his skills designing a temporary architecture, around the processes that ultimately produced a more permanent (and often less interesting) one, to a more stable constituency, the blue and white collar work force of the early twentieth century, when they still occupied a single urban unit, the industrial plant.

Unlike Taylor and Gantt, whose graphic projection instruments drew primarily on the more abstract data visualization tools of economics, Gilbreth mixed various media, including the instruments of Taylor and Gantt, the orthographic projections and physical models of engineering and architecture, as well as the new media of photography and film that had already been experimented with by 19th century physiologists. Lillian Gilbreth's training in psychology reinforced her husband and partner's existing proclivity for multimedia visualization and projection, by arguing that this approach allowed for a much broader engagement of participants in the laboratory method than had previously been possible. As I have shown through their the analysis of their first instruction cards, the Gilbreths' visualization theory mirrored the logics of an architectural drawing set, with the relationships between projections of various scales and coordinates, being carefully coordinated to provide a synthetic mapping of a particular artifact. Whereas earlier treatises on orthographic and perspectival projection sought to precisely visualize some collection of static objects, the Gilbreths' visualization theory offered a similar set of techniques for precisely describing and projecting processes in space-time.

While the Gilbreths' visualization theory has been well known since its inception, a study of its application to modern architecture has been prevented by a number of assumptions. What I have shown is that the Gilbreths focused on two issues central to architectural production, the preparation of projection instruments and methods and the

use of those projection instruments to manage the *conception* of architectural products, in the form of drawing sets, the *construction* of artifacts, derived from those products, as well as a consideration for the constituencies that occupy these artifacts, during and after construction.⁴⁶⁴ The Gilbreths' visualization of the laboratory method went one step further, supporting not only the systematic management of architectural production, but the scientific management of new standard methods and parameters of architectural production, through what Le Corbusier called *laboratory work*, Martin Wagner called *practical experiments*, Ernst May would call the *evolving of types* (retaining Muthesius' older terms) and what the German government would refer to as the "research of systematically managed methods of building and dwelling", through *experimental settlements*. In the subsequent chapters, I will examine a series of case studies of the laboratory method, as applied to architectural production.

⁴⁶⁴ These terms are borrowed from Le Corbusier, "Maisons En Série," *L'Esprit Nouveau* 13(1922). I will explain them in more detail in Chapter 4.

Chapter 3. Managing Settlement-Building: Town-Planning and Construction Plan Management, 1909-1918

In the December 1926 issue of *Das Neue Frankfurt*, Ernst May, the architect managing Frankfurt's municipal housing program, published his first experimentally derived unit type, the first in a series of studies that would inform the Frankfurt System of Mountable Panels.⁴⁶⁵ Within that same issue, May, the journal's editor, included the "experimental building site" established by Walter Gropius at Dessau, where that architect had derived the first in a series of three types.⁴⁶⁶ Also included was a discussion of two other *experimenters*, that of Le Corbusier, who had recently completed the first phase of his *Wohnviertel Fruges in Pessac (Bordeaux)*, and that of John Conzelman, an American engineer who had translated his system of fabrication and construction, through a project in Ohio, between 1917-1919.⁴⁶⁷ Both *experimenters* had derived standard methods through their laboratories, with the French architect standardizing a method of architectural production, through an engagement with already standardized fabrication and construction techniques, and the American engineer standardizing his method of fabrication and construction, initially developed for both *infrastructure-* and *factory-building*, for application to settlement-building, through a collaboration with the architecture and town planning firm, Herding and Boyd. May did not directly apply these standards to his work, but rather he used both projects as models for what might constitute

⁴⁶⁵ Ernst May, "Mechanisierung Des Wohnungsbaues," *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 2(December 1926).

⁴⁶⁶ Walter Gropius, "Der Grosse Baukasten," *ibid.*

⁴⁶⁷ Le Corbusier, "Die Neuen Wohnviertel Frugès in Pessac (Bordeaux)," *ibid.* 1926-27, no. 2. May discussed the Unit System in Ernst May, "Mechanisierung Des Wohnungsbaues," *ibid.* 2. By that time he assumed his readers were already familiar with the more extensive publications of this system, as well as the Atterbury System, from a series of articles written by Martin Wagner and Bruno Taut on these projects in *Wohnungswirtschaft* between 1924 and 1925.

the laboratory method as applied to architecture. His translation of the approaches that had been experimented with in France and America, was assisted by his existing familiarity with two methodologies utilized within both projects: the theories and visualization instruments of scientific management, as well as a system of settlement design put forth by Raymond Unwin's town-planning techniques. Unwin, the English architect most famous for designing Letchworth Garden City and Hampstead Garden Suburb, for whom May had worked, had developed a design methodology in which various urban morphologies, including perimeter blocks, quadrangles, slabs or residential streets had been rationalized to a common unit scale. Essentially, this methodology was the urban design equivalent of the system of interchangeable parts on which modern manufacture had been based. *Town planning in theory and practice* was to Le Corbusier's laboratory at Pessac, or Gropius and May's experimental settlements in Germany, what systematic management had been to scientific management, a foundation onto which the new approach could be appended. By coupling Unwin's site design and visual planning principles, which allowed one to manage the design of a settlement at the scale of the housing unit, with the visualization theories of the Gilbreths, modernist architects could now manage the settlement at the scale of the building component, as well as the housing unit. Furthermore, they were able to apply the laboratory method, using the iterative nature of houses in groups or series, as a means of evolving types.

In this chapter I will first analyze the theories and methods included in Raymond Unwin's highly influential 1909 manual, *Town Planning in Practice*. Next, I will contextualize John Conzelman's "pioneering experiment in reforming housing delivery

from the ground up"⁴⁶⁸, the Unit System, by comparing his collaboration with a team of architects who had used Unwin's manual, to two concurrent systems of industrialized settlement, the Atterbury System, developed by the American architect Grosvenor Atterbury, and the Harms and Small System, developed by the American engineers, Henry Harms and George Small. As will be demonstrated, the development of the latter approaches was hindered by limited interdisciplinary collaborations, as well as a less complete application of the Gilbreths' visualization instruments and Unwin's site design and visual planning principles.⁴⁶⁹ In the next chapter, I will shift from Conzelman's "ready-made houses"⁴⁷⁰ to Le Corbusier's and Peter Behrens' attempts to rationalize architectural production, in order to manage the design of artifacts at the scale of the pre-modern urban unit, a town or village, and an industrial product, a window or door, simultaneously.

Unwin's *Via Lateralis* Toward the 'Conscious Art of Town-Building'

Although Raymond Unwin (1863-1940), an English architect and town planner, had been trained in formal composition by John Ruskin, social activism by William Morris, and in mining engineering, through a formal apprenticeship concurrent with Taylor's at Midvale Steel, he has often been overlooked as a result of his affiliation with the Garden

⁴⁶⁸ "Mechanisierung Des Wohnungsbaues," 35.

⁴⁶⁹ The most thorough discussion of Atterbury's work to date is included in Peter Pennoyer and Anne Walker, *The Architecture of Grosvenor Atterbury* (New York: W W Norton & Co., 2009). The work of Harms and Small has received relatively little attention from scholars. The most extensive discussion of their system is included in a footnote of Tom F. Peters, *Building the Nineteenth Century*: (Cambridge: The MIT Press, 1996). Their work in Holland is also briefly discussed in Tjeerd Boersma, *Betondorp: Ontwerp, Maatschappij, Techniek* (1987).

⁴⁷⁰ Conzelman referred to his work as "ready made houses" in a lecture on the subject. John E. Conzelman, "Ready-Made Houses," in *Proceedings of the Sixth National Conference on Housing: Housing Problems in America* (New York: National Housing Association 1917). The only reference to Conzelman's important work, that I have found, is included in Amy Slaton, *Reinforced Concrete and the Modernization of American Building, 1900-1930* (Pittsburg: Johns Hopkins University Press, 2003).

City movement and its founder, Ebenezer Howard.⁴⁷¹ However, Unwin, and his partner Barry Parker, a more formally trained architect, had a significant career, designing worker's settlements, middle class residences, and publishing their ideas on architecture and urbanism, before they were given the charge of designing what would be the first garden city, Letchworth, in 1903.⁴⁷² While the term 'town-planning' has often been used synonymously with urban planning, many of Unwin's techniques were really intended for architects to use in designing artifacts at the scale of the pre-industrial urban unit, the village, and the intricacy of the cottage, through a reliance on the same "principles of organization the application of which to our great industries during the past century has led to such increased efficiency."⁴⁷³ (Fig. 41) Unwin not only provided projective instruments for town planning, he also formulated a theoretical critique of the modern suburb, with its identical single-family houses repeated along *wiggly* streets, one that combined the new principles of industrial organization with a persistent admiration for the vernacular built environment, a model that could no longer be copied but that needed to be

⁴⁷¹ Andrew Saint, "Unwin, Sir Raymond (1863–1940)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004).

⁴⁷² The best account of their work before Letchworth is included in Walter Creese, "Parker and Unwin: Architects of Totality," *Journal of the Society of Architectural Historians* 22, no. 3 (Oct. 1963). Creese's collection of Unwin's writings also chronicles his publishing activity before *Town Planning in Practice, The Legacy of Raymond Unwin: A Human Pattern for Planning* (Cambridge: The MIT Press, 19__). His work is distinguished from the ideas of Howard, as well as the earlier garden suburbs designed in America, in *The Search for Environment: The Garden City, before and After* (Baltimore: The John Hopkins University Press, 1992 (1966)).

⁴⁷³ Raymond Unwin, "Introduction to the Second Edition," in *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1911). Although Unwin never explicitly discussed scientific management, his own engineering training, as well as his knowledge of industrial plant organization, as had been seen at Cadbury and Lever Soap, where the first garden villages of Bournville and Port Sunlight were constructed, gave him a foundation in "systems thinking" comparable to that of Taylor, Gantt or Gilbreth. Port Sunlight was literally an extension of Lever's industrial plant, as is clearly visible in the settlement plan for the "Arbeiter Kolonie – Port Sunlight", published in Josef Stübben, *Der Städtebau*, 2 ed., *Handbuches Der Architektur* (Stuttgart: Alfred Kroner, 1907), 348. or in a birds-eye-view perspective of the "Present Works at Port Sunlight, 1910", published as a postcard in 1912.

studied.⁴⁷⁴ (Fig. 42) *Town Planning in Practice* was the result of a decade of work in designing and publishing, paralleled by Unwin's active lobbying to reform the current mode of housing delivery by decreasing the central authority of the By-laws and increasing the spatial and economical planning powers of local councils.⁴⁷⁵ The purpose of this manual was to assist in the more localized decision-making process and to promote the role of the architect, in lieu of the landscape architect, in town planning. It was Unwin's finer grained, unit-scale resolution of the settlement as a design problem that distinguished him from the landscape-architect town planners, as well as from the approach of the most influential theorist of architectural city-building, prior to 1909, Camillo Sitte (1843-1903).⁴⁷⁶ Unwin's

⁴⁷⁴ For example, Le Corbusier's persistent admiration for the "harmony" of vernacular built environments as well as his mode of critique of French "garden cities", through a direct comparison to more efficient industrial plants, is both compatible with and attributable to Unwin's manual, as I will show in Chapter 4. For a specific example of this, see Le Corbusier, "Vers La Ville Radieuse - Vivre! (Habiter)," *Plans* 4 (April 1931). On the last page of this article, he pairs an image of a fishing village, the positive example lost to modern civilization, with an image of a *cit e jardin* next to massive rail depot, a negative example of an "arbitrary" urban "organism".

⁴⁷⁵ Unwin's primary intended audience for this manual was the English architect, who would soon have a new type of client, the local council, empowered by the Town Planning Act of 1910 to plan and manage itself both spatially and economically. Prior to the passage of this Act, local councils could not engage in town planning, and architects were trained and primarily interested in the building, or product scale. Unwin's successful lobbying efforts were the result of a productive collaboration with Liberal MP John Burns. Such efforts resulted in the Hampstead Garden Suburb Act of 1906, allowing him to use a large parcel of land recently incorporated and connected, by rail, to London proper, "for the purpose of experimenting on a large scale in the development of new towns and suburbs". Hampstead would serve as a laboratory for the 1909 manual, as well as the legislation included in the Town Planning Act of 1909. English "urban communities" would now be "able to apply to the development of their towns, and to the economic use of the opportunities afforded by their sites and the resources which have developed upon them, those principles of organization the application of which to our great industries during the past century has led to such increased efficiency." Introduction to *Town Planning in Practice*, Second Edition, 1911.

⁴⁷⁶ A number of scholars have pointed to the architectural impact of Unwin's techniques. The first to make this argument in relation to Le Corbusier's work was Robert Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier* (Cambridge: MIT Press, 1982), 178-80. Since then, Le Corbusier's interest in Unwin, even more so than Camillo Sitte, has become evident, through the discovery of his unpublished manual of urban design, Charles-Edouard Jeanneret, *Le Construction Des Villes* (La Chaux-de-Fonds 1987 (1910)). Richard Etlin has argued that Le Corbusier utilized the visual planning of Sitte, Unwin, as well as Auguste Choisy, to scale the methodologies of the medieval town and Hellenic temple complexes to the architectural scale, starting with the Villas Roche Jeannerette. Richard Etlin, *Le Corbusier and Frank Lloyd Wright: The Romantic Legacy* (1994), 115. One of the broadest discussions of the persistent influence of visual planning on architecture is included in John MacArthur, *The Picturesque: Architecture, Disgust and Other Irregularities* (2007). Recent scholarship in Germany has uncovered the more direct influence of specific organization schemes from *Town Planning in Practice* in Muthesius' section of Hellerau and in Walter Gropius' initial work at Dessau. Laurent Stalder, *Hermann Muthesius, 1861-1927: Das Landhaus Als*

manual reinvigorated Sitte's earlier design methodologies, through a critical assessment and a marked shift, from a more passive and stereotonic urban fabric punctuated by public buildings, to a more active fabric, built up of architectural units whose relationships to the lines of traffic, topography and parcel ownership, forming space and place, were more dynamic than deferential. (Fig. 43) Unwin's own site design, visual planning and interchangeable system of architectural units and urban groupings provided modernist architects a foundation onto which they could apply the visualization theories of the Gilbreths and the laboratory method of Taylor. (Fig. 44,45)

Unwin began his manual with a critique of the "modern suburb" that was so prevalent in turn of the century England, with its "endless rows of brick boxes", its "dreary streets and squalid backyards".⁴⁷⁷ He vehemently argued that these were "not really homes for people", no matter how "complete may be the drainage system", provided by "engineer town planners", or "detailed the by-laws under which they are built".⁴⁷⁸ "The spirit in which the modern suburb had been built up" was inherently flawed, as it lacked an "adaptation to the site surroundings", or site design, and possessed "no imaginative fitting of it into a picture", or visual planning. As a whole, "little thought [had been] bestowed on the individual building", as it was the product of a "stock plan ... reproduced in row after row without regard to levels, aspect or anything".⁴⁷⁹ For Unwin, if modern town planning were

Kulturgeschichtlicher Entwurf. (Zurich: GTA Verlag, 2008), 142-43. Andreas Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm* (Dresden: Thelem Universitätsverlag, 2010), 25.

⁴⁷⁷ Raymond Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1909), 4.

⁴⁷⁸ Ibid. The By-laws had been lobbied for by an earlier generation of Liberal urban activists, in whose steps the young urban designer had followed. A good overview of the history of these By-laws is included in Creese, *The Search for Environment: The Garden City, before and After*. Stübgen provided a survey of the German equivalents in Stübgen, *Der Städtebau*.

⁴⁷⁹ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 12.

to be successful, it would need to address the scale of the settlement and the unit simultaneously.

Throughout the manual, Unwin distinguished between two schools of planning, *formal* and *informal*. While he openly acknowledged his own admiration for “informal beauty”, he was equally critical of the “theories of formalism and informalism” which he felt had developed into “prejudices held without real appreciation of formality of design and informality of the site”.⁴⁸⁰ For Unwin, all modern planning was inherently formal, in the sense that it was artificial; it applied an order through a predetermined *plan*, a *drawing* or a *sketch*. Planning could strive for *formal beauty*, applying a new order to given conditions, or it could *frame*, or be the *setting* for, various contingencies derived from the specificity of a particular site. His real goal in the 1909 manual was what he called a “*via latioria*”, around the formal/informal impasse, rather than a “*via media*”, or compromise, which would require the architect to “think out for himself the abstract question of formalism as opposed to informalism” and the “relative importance of ... symmetrical design” versus “maintain[ing] existing characteristics of the site”.⁴⁸¹

Unwin’s lateral road first wound through a critique of the *irregular* German town planning school, the orthodox followers of Camillo Sitte, as well as the *informal* English town planning school, informed by the “landscape school” of garden design, two methodologies that were nevertheless based on models closest to the architects own heart, the medieval town and wild nature.⁴⁸² He explained that Camillo Sitte had concluded that

⁴⁸⁰ "Introduction to the Second Edition," XIV.

⁴⁸¹ *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 125. Unwin believed that England’s “lack (of) a city-building school” of its own made it an ideal site for this endeavor.

⁴⁸² In Germany, as Unwin and other proponents of the Town Planning Act often pointed out, not only did municipalities already enjoy “town planning” powers, but architects were the primary settlement designers.

“typical medieval towns” were not simply the result of “natural growth”, but that their “very distinct framework of lines”, as well as their “sense of scale and proportion”, suggested a “definitive sense of design”, despite having “nothing of regularity” in their geometry.⁴⁸³ “(S)o much system and art” found in the “irregularities (of the) medieval town”, wrote Unwin paraphrasing Sitte, “must have been (the result of) conscious planning and design.”⁴⁸⁴ Unwin began this critical assessment of Sitte’s theories by offering his own characterization of medieval planning. He explained that the “setting of the buildings was done largely on the ground by the eye”, as opposed to the modern method of planning, which “transferred” the design of a site “from a paper plan”.⁴⁸⁵

In the illustrations of his manual, and at Hampstead, Unwin would attempt to simulate a form of unconscious planning. He and Parker would prepare a highly abstract and simple “organizational scheme” before “giving (it to) an artist”, usually Charles Paget Wade, who would then create an image of a “picturesque old town street” or a “picture of a landscape”.⁴⁸⁶ (Fig. 46) Although even these fanciful renderings were rooted in the basic elements of building and dwelling for their “effects”, Unwin explained that the “building up

As such, this particular design problem was deeply integrated into the discipline, as well as its formal training.

⁴⁸³ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 52.

⁴⁸⁴ Ibid. Sitte sought to prove that the medieval model was in fact just as rational, if not more so, than the Classical one,

⁴⁸⁵ Ibid.

⁴⁸⁶ One good example of this collaboration is included on page 249 and 250, where a particularly difficult intersection is further elaborated into imaginary scenes. Le Corbusier included the same intersection in Jeanneret, *Le Construction Des Villes*. Another example is included on page 346-347, where a plan showing “groups of buildings designed to maintain square roof lines on a curving road” is transformed into an “(i)maginary sketch of a village scene where the buildings are square with each other on a road curving”, as per Unwin’s scheme. The same approach was practiced in the actual design of the groups at Hampstead, where Parker and Unwin first tried out a particular morphology, then developed a more abstract organizational scheme that in turn served another architect, such as M. H. Baillie Scott or Edwin Lutyens. A good example of this approach is included on Page 343.

of a town is not accomplished by the making of such a sketch design.”⁴⁸⁷ This process was a surrogate for the “unconscious result of the influence in which the whole building profession was steeped” during the Middle Ages.⁴⁸⁸ That “tradition” had “acted unconsciously”, “almost as a natural force”, leading to an “absence of symmetry” while at the same time maintaining an “orderly arrangement”.⁴⁸⁹ This unconscious force was evident within “the picturesqueness of the architectural groupings”, as well as the “simplicity of treatment”, the “absence of decoration and ornament”, the “general use and skilled handling of materials most readily accessible”, and the general “avoidance of ... extravagance”.⁴⁹⁰ A conscious attempt to achieve the same end, “even where the artist himself [was] given absolute control of every detail of the work”, would certainly “fall short of his mental picture”, which was based upon the medieval model and in competition with what Unwin referred to as “modern conditions”.⁴⁹¹ So while the “study of old towns”, as well as “their buildings”, was “most useful”, even “essential”, for Unwin, they had “arose from conditions ... which no longer exist[ed]”, and it “would take generations for any new tradition comparable to the old one to grow up”; one could therefore “admire”, but it would be “unwise to seek to reproduce it.”⁴⁹² The German school was in “danger of regarding these principles as the only ones of great importance”.⁴⁹³

The “modern suburb” lacked both the “natural growth” of pre-modern urban fabric, which had been “so gradually ... adapted to its pace” and “assimilated into the whole before

⁴⁸⁷ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 126.

⁴⁸⁸ *Ibid.*, 52.

⁴⁸⁹ *Ibid.*, 12.

⁴⁹⁰ *Ibid.*

⁴⁹¹ *Ibid.*, 13-14.

⁴⁹² *Ibid.*

⁴⁹³ *Ibid.*, 112.

the next was added”, as well as tradition to direct this process.⁴⁹⁴ While the old town may have been unconscious, the modern town was certainly not consciously planned. Instead, it was the result of a “haphazard system of development”, an agglomeration of partial regulation and the individual speculation that marked early industrial capitalism, resulting in “mere aggregations of people” rather than “consciously organized communities.”⁴⁹⁵ It was therefore requisite that the architect-turned-town planner “consider (the) best results” possible “under modern conditions”, necessitating a mindfulness for the “rapidity of ... growth”, the “wholesale character” of the development, and the “means at our disposal”.⁴⁹⁶ Regardless of what models the architect admired, “modern conditions require[d] ... a definite plan” founded on contemporary building and societal practices, and “under the rules of conscious and ordered design”.⁴⁹⁷

Unwin critiqued the German school’s work for their adherence to one of Sitte’s more questionable arguments, which attributed “the picturesque and beautiful” qualities and “convenience of traffic” found in vernacular architectural groupings to the “devious lines and varying widths of streets” and “irregular places planned with roads entering them at odd angles”.⁴⁹⁸ (Fig.47) Unwin found that the German school’s quest to “reproduce” these formal and functional traits “consciously”, “along irregular lines”, had produced highly inconvenient schemes for modern traffic at the macro level, lacking the “framework” of primary routes, as well as dysfunctional building lots that prevented the “picturesque

⁴⁹⁴ Ibid., 13-14.

⁴⁹⁵ Ibid.

⁴⁹⁶ Ibid.

⁴⁹⁷ Ibid.

⁴⁹⁸ Ibid., 97-98. Illus. 71 Prize Plan of Pforzheim by Herr Thomas Langenberger and Illus. 78 Municipal Building Plan for Zschernitz, near Dresden. Both were reproduced from issues of *Der Stadtebau* magazine.

groupings” they so sought after.⁴⁹⁹ For Unwin, these schemes may not have been formal but they were certainly formalist, finding the “irregularity in their work ... to be introduced for its own sake”, “aimlessly” and “without adequate reason”.⁵⁰⁰ Such examples concluded that the “artificial imitation of accidentally produced features” was not likely to “lead to successful results in the hands of modern builder” who had “lost touch with tradition”.⁵⁰¹ While critiquing some of Sitte’s central arguments, Unwin also reproduced a number of his organization schemes, showing graphically that Sitte also believed that spatial and temporal complexity could be achieved along “regular lines”.⁵⁰²

Unwin then analyzed English garden design, and particularly the “landscape school”, whose own preference for “informal and meandering plans” had dominated “the towns and suburbs laid out during the last century”.⁵⁰³ (Fig. 48) As with the discussion of the Germans, Unwin first turned to the *model* on which the design *methodology* had been based, wild nature. While the “beauty of wild nature”, the “slopes of the hills and valleys”, “the bend of the river”, “the curve of the bay” or “the forms of the trees and the shrubs”, was “usually informal” in appearance, it was not the “result of chance or of freedom from

⁴⁹⁹ Ibid.

⁵⁰⁰ Ibid., 112.

⁵⁰¹ Ibid., 113.

⁵⁰² Unwin included much of the chapter on “Improvement to the modern system”, where Sitte also demonstrated, “how far it is possible to comply with these principles”, in reference to those found in the medieval town, “in designs based upon more regular lines”. Camillo Sitte, “Improvements in the Modern System,” in *The Art of Building Cities: City Building According to Its Artistic Fundamental* (London: Martin Fine Books, 2013 (1889)).

⁵⁰³ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 126. Unwin discussed Bournemouth, Eastborn and Buxton. He did not mention his own application of this approach at Letchworth, which was clearly influenced by landscape architect Thomas Mason’s work on the first phase of Port Sunlight. The Port Sunlight plan was published in Stübben, *Der Städtebau*, 348. His own work, prior to Letchworth, as well as after, at Hampstead, was more regular in its lines. While the first scheme for Hampstead did include “meandering” roads, a network of straight, or slightly curving, roads later replaced them. The first Hampstead scheme was published in *Town Planning in Theory and Practice*, Town-Planning Conference (London: The Garden City Association, October 25, 1907), 10. It was replaced with the more regular lined final scheme for Hampstead, included as a foldout map, in the 1909 manual.

restraint”.⁵⁰⁴ Instead, it was a “result ... of obedience (to) complex ... laws”, as well as the “forces of weather and gravity, the strengths of materials and chemical reactions resulting from their play”.⁵⁰⁵ While architects could share in an “admiration for the beauty of wild nature”, and could even “place that beauty on a level far higher than any attained by man’s handiwork”, he argued that they “should not adopt (the) methods” of the landscape school and “attempt to reproduce the effects which have resulted from the interplay of natural forces”.⁵⁰⁶ Such an attempt was “futile” because “the conditions of natural growth are so complex” that to “reproduce” them would “at best (result) in a parody” and at worst, “a caricature”.⁵⁰⁷

The eventual goal was not to discover these complex laws, but to learn how human settlement might engage them. Foregoing the imitation of wild nature, as well as the application of the “meaningless and often fussy patternmaking” of the “formal school” of garden design, he advocated for the provision of a “simple frame and setting” which complimented both nature and site contingencies.⁵⁰⁸ As Unwin explained, nature “will in no way be helped by (the) disorderly lines of our terraces”, since “blooms will be as lovely on the straight terrace.” As such, a frame could best achieve the “aims of informal beauty” when it was “carried out on a simple and orderly plan”, which might appear formal, but would, to the eye, “secure ... [the] natural beauty” found within “the most informal

⁵⁰⁴ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 119.

⁵⁰⁵ Ibid.

⁵⁰⁶ Ibid.

⁵⁰⁷ Ibid. John Ruskin, Unwin’s drawing teacher, had encouraged students to study natural laws, as well as social ones, in order to inform their pictorial compositions. John Ruskin, *The Elements of Drawing: In Three Letters to Beginners* (New York: Wiley & Halstead, 1858).

⁵⁰⁸ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 120.

setting.”⁵⁰⁹ With the appropriate respect for informal beauty, the town planner could turn to the “formalist” for guidance as to how “all these effects”, inherently artificial and artful, could “be obtained”, using a simple geometry.⁵¹⁰ It was Unwin’s hope that such a design approach might generate “other forms of beauty”, distinct from those based on earlier models, such as the medieval town, wild nature, or the Classical temple, and more “adapted to our present conditions”.⁵¹¹ Although Unwin remained vague as to what that approach might be, his rigor in clarifying the differences between aesthetic models, the contexts in which they were generated and the methods with which one might work, provided a platform for others architects to experiment and standardize.

Unwin augmented these detailed critical analyses of the two dominant informal schools with numerous examples of a formal frame applied to informal site conditions with an admiration for informal beauty. Using “definitively designed ... towns” from a range of places and times, the reader was to “think out for himself the abstract question of formalism as opposed to informalism”, by considering “the relative importance of ... symmetrical design”, or of “maintaining existing characteristics of the site” on a case by case basis. Unwin was critical of plans, which were too deterministic at either the macro scale of frame or the micro scale of building groupings, resulting in the detriment of the

⁵⁰⁹ Ibid., 121. Like Sitte, members of the landscape school, particularly Patrick Geddes, had “taught (architects) the importance of the careful study of the site”, not only in deference to its current condition, but with a view towards its “possibilities”.

⁵¹⁰ Ibid., 125. Conscious of the confusion that his use of the terms formal and informal might engender, Unwin advised that formal techniques should be used as a “method of carrying out definite aims, and not as an end in itself, justifying either the destruction of existing beauty or the creation of formality for its own sake.” All beauty was “elusive” and “not always easily attained by direct effort”. Following a line of reasoning rooted in romanticism, Unwin repeatedly distinguished his own methods from a “regard for a type of beauty which it is beyond (ones) power to create”, but should nevertheless be sought out.

⁵¹¹ Ibid., 13-14.

opposite.⁵¹² While he gave more formal approaches to town planning in France, America and Germany, equal attention, he showed clear preference for a particular blend of formal frame and informal infill.⁵¹³ Unwin praised a series of medieval English new towns, built in southwest France and laid out along “fairly regular lines”, but sharing much of the “individuality” of their more gradually grown contemporaries.⁵¹⁴ Quite in contrast to the irregular German school, whose members believed that complex street geometries would ensure picturesque architectural groupings, here it was the introduction of a variety of building types, as well as slight adjustments to the rectilinear geometry, acting less as a grid and more as spine, that had contributed to the “line of these streets (being) slightly broken at junctions”; therefore it was the “opposite side of the road not being exactly opposite the previous line of the road”, which had resulted in “street vistas ... closed by buildings”.⁵¹⁵ (Fig. 49) These precedents would inform most of Unwin’s abstracted “organizational schemes” included later in the manual.⁵¹⁶ The relationship between a more formal frame, defined by a simple, generally rectilinear traffic grid at the macro scale, combined with

⁵¹² Ibid., 114.

⁵¹³ Ibid., 62-69. In terms of more formal work, he discussed how Haussmann’s “junctions” were “cunningly disposed to show up all the public buildings from the maximum number of points of view” but resulted in complicated building lots. Conversely, within the American system of planning, the infinite “trellis pattern” of the idealized building block compromised traffic. Although 18th century German new towns followed the “straight formal lines typical of the Renaissance work”, they still achieved “variety”, through “different street widths”, a “certain number of diagonals” assisting in traffic coordination, as well as a “relation” to existing landscape features, fabric and monuments.

⁵¹⁴ Ibid., 59-62. Montpazier and Aigues Mortes were included as examples.

⁵¹⁵ Ibid., 60. While Unwin tended to break both sides of the street line at Hampstead, through architectural groupings, later modernist settlements, such as the *Quartiers Moderne Fruges* by Le Corbusier or the *Praunheim Siedlung*, by Ernst May combined a straight and broken street line, just like the diagram had.

⁵¹⁶ The most distilled version of these precedents is the “Plan and sketch of street showing one side the uninteresting vanishing perspectives of the unbroken building line, and on the other the more picturesque result of the breaks.” Page 259. This diagram was informed by a study of Stradun street in Ragusa (Dubrovnik), made by Josef Stübben, and included in Unwin’s manual, pg. 60. The breaking of a line in the landscape also drew more generally on the compositional theories of Unwin’s former drawing teacher, John Ruskin. Ruskin used Albrecht Dürer and James Turner’s landscape paintings, as well as more abstract compositions, such as the geometric ornamentation found in Bibles, in his teachings. These principles are included in his publication intended primarily for young artists, Ruskin, *The Elements of Drawing: In Three Letters to Beginners*.

groupings of building, somewhat intentionally independent from but in dialogue with the traffic grid, at the micro scale, was the subtle but consistently advocated road towards a modern urbanism.⁵¹⁷

Unwin's route towards a *conscious modern town-building*, one that hoped to draw its complexity from a close study of the site, in geological, meteorological, botanical, cultural and social terms, also reflected a local disciplinary influence common to all of the members of the English domestic architecture scene, that of August W. Pugin.⁵¹⁸ It was Pugin's proto-functionalism that informed Unwin's novel model of architectural production and distinguished it from the principles advocated by Sitte. Unwin's techniques, at the settlement scale, followed a logic similar to that of Pugin's theorization of the design principles behind Oxford's Colleges. "(A)t a distance", argued Pugin, each one of these ensembles "presents a complete grove of towers, spires, and pinnacled turrets, rising from the colligate church," utilizing a common set of elements to generate a "distinguishing character and elevation".⁵¹⁹ Each College could also be broken down into a unit, discernable in the overall ensemble through its chimney. Pugin discussed the chimney as a unit of formal organization at the scale of the College, as well as a functional unit, which benefited each individual unit spatially, in terms of fire protection, structurally, acting as a buttress to

⁵¹⁷ Two of the most visually clear historical examples of this principle were Chester, England and Aosta, Italy. While these towns began as definitively planned roman camps, they grew more gradually and unconsciously during the Middle Ages within the Roman frame, which continued to define the primary traffic arteries and the main "places" of the town without dictating the plasticity of the urban space. A very similar relationship was also presented through the numerous plans of Oxford, Unwin's home town, where more informal street lines, following topographic contours, at the macro scale, were contrasted by a mixture of smaller row houses and the large quadrangles of the various Colleges, driven first by an internal organizational logic and second by the position of the traffic corridor.

⁵¹⁸ As Henry Russell Hitchcock has alluded, much of what would later be called modernist functionalism can be traced back to this design treatise, and particularly the English Gothicists' analysis of Oxford's colleges, which hover between architecture and urban ensemble. Henry Russell Hitchcock, *Early Victorian Architecture in Britain* (New Haven: Yale University Press, 1954), 76-77.

⁵¹⁹ Augustus Welby Pugin, *The True Principles of Pointed Christian Architecture* (London 1841), 51.

the exterior walls, as well as formally, by providing a “great variety of light and shadow, and a succession of bold features”.⁵²⁰ (Fig. 50) Shifting from the interpretation of this particular model to that of a more general design philosophy, Pugin explained that:

An architect should exhibit his skill by turning the difficulties (that) occur in raising an elevation from a convenient plan into so many picturesque beauties; and this constitutes the great difference between the principles of classic and pointed domestic architecture. In the former he would be compelled to devise expedients to conceal these irregularities; in the latter he has only to beautify them. But I am quite assured that all the irregularities that are so beautiful in ancient architecture are the result of certain necessary difficulties, and were never purposely designed; for to make a building inconvenient for the sake of obtaining irregularity would be scarcely less ridiculous than preparing working drawings for a new ruin. But all these inconsistencies have arisen from this great error—the plans of buildings are designed to suit the elevation, instead of the elevation being made subservient to the plan.⁵²¹

Unwin sought to achieve this approach in his “principles of design”. The study of one’s site, “the people and their requirements”, wind direction, solar orientation, local vegetation, topography, local “building materials (and) traditional methods of building found within the locality” and even the idiosyncrasies of one’s collaborators were all *difficulties* whose engagement, translation and framing could do for conscious modern town planning, what unconscious tradition and a more gradual rate of development had done for the medieval town and what natural forces continued to do for wild nature.⁵²² Rather than leading to “commonplace designs” or requiring one to “subordinate the main effect to trivial

⁵²⁰ Ibid., 52. The illustration, “General Prospect of St. Mary Magdalene College” is between pages 50 and 51, the drawing of the chimney is on page 52.

⁵²¹ Ibid., 63. Muthesius used essentially the same language to valorize the work of Norman Shaw, particularly Lyes Wood in Hermann Muthesius, *The English House, Volume I: Development*, trans. Janet Seligman (London: Frances Lincoln Ltd., 2007 (1904)). He also disagreed with Ruskin, who minimized Pugin’s importance, and instead pointed to his influence on English domestic architecture in *Style-Architecture and Building Art: Transformations of Architecture in the Nineteenth Century and Its Present Condition*, ed. Harry F. Malgrave, trans. Stanford Anderson, The Getty Center Publication Programs (Santa Monica: The Getty Center, 1994 (1902)). Morris himself had made essentially the same argument in William Morris, “The Revival of Architecture,” *Fortnightly Review* (1888). Pugin’s *faith* in a rational process generating aesthetic qualities, somewhat unconsciously, would continue to influence modern architects well after neo-Gothic expression fell out of favor.

⁵²² Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 145.

convenience”⁵²³, Unwin saw the more simple framing of complex processes as the main route towards a new kind of architectonic artifact.

This approach is clearly evident in Unwin’s own summary of his approach to settlement design. He encouraged the designer not to start with a particular geometric pattern, curved or straight, gridded or diagonal, but to instead first identify key nodes, primary and secondary centers for communal life, on the site. The nodes were then to be connected with a framework of traffic arteries, which would “divide up the area ... into a series of space”, essentially super blocks that were later divided into a “secondary series of less important roads” or paths. While the primary roads could follow their own logic, the secondary roads should “lead into the main roads ... at right angles to them, so that the facades of buildings on the main roads shall not be spoilt by a constant repetition of awkward junctions.” The interior street and parcel logic of each space could, and even should “be treated with an individuality of its own.”⁵²⁴ For this reason, he defined roads as “primarily highways for traffic” and as “sites for buildings”, and not as the primary tool of place and space making, as had been the case with a number of earlier modern town planning approaches. It was not the geometry of roads, “straight or curved” that ensured “the character of the street”, as so many of the “aimless wiggles” of the landscape school had already demonstrated.⁵²⁵

⁵²³ Ibid., 151. Nikolaus Pevsner would have a difficult time explaining this lateral route to form to postwar British theorists, especially his student Reyner Banham. For more on this see Anthony Vidler, *Histories of the Immediate Present: Inventing Architectural Modernism* (Cambridge The MIT Press, 2008). Vidler’s study provides a valuable account of how many of the radical ideas of romanticism were removed from interwar modernism by postwar theorists, who tended to emphasize the older ideas of the 18th century. This has recently been partially corrected by the publication of Mathew Aitchinson, ed. *Pevsner’s Townscape: Visual Planning and the Picturesque* (Los Angeles: Getty Research Institute, 2010).

⁵²⁴ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 278.

⁵²⁵ Ibid., 318. “Trellis streets” were problematic, for while they were “convenient and economical for the building blocks”, they produced a “monotonous effect” and were unsuitable for traffic planning, whereas

This more rational approach to the overall “frame” of a settlement was not intended to generate a rationalistic impression, but to allow the designer to discover a spatial and temporal artifact, through a protracted process of engagement. To prove his point, Unwin offered a series of examples of how formal design methods produced irregular beauty, and vice-versa. A “road line which [is] formal and straight on ground plan” may “because of the undulations of the ground” suggest a more “informal and broken” massing is the correct approach, just as an “informal line” of a road way, “following closely the contour of the site” may suggest a more “formal” or unified massing for the grouping of buildings. The grouping of buildings by an architect would also determine whether a complex “junction shall be capable of becoming a fine artistic creation or shall be a mere jumble of awkward corner blocks”. While Unwin recommended studying the complex resolutions of what were often self-induced geometric problems of the German school, he warned not to “neglect the broader elements ... in undue concentration on a somewhat forced picturesqueness of treatment in the minor details.” Along these lines, he encouraged a lateral approach to a landscape feature or traffic condition⁵²⁶, one that framed that condition through the use of “simple, orderly, broad lines of design” and even “of formality and symmetry in architectural groupings”.⁵²⁷ (Fig. 51) In a series of studies looking at particularly complex

“diagonal streets” were convenient for traffic but did not “produce satisfactory buildings, or beautiful open spaces.”

⁵²⁶ Ibid., 314. One of the most influential examples drew on Verona in order to demonstrate how to deal with a gradual topographic feature. Instead of simply ignoring it or introducing a serpentine street, Unwin recommended a generally straight traffic corridor from which secondary roads, only partially planned following the contours, would lead to building parcels. Such an arrangement would require less site excavation, secure better views, maintain ample cross ventilation and provide ideal floor plan arrangements, more so than if the buildings were built along the traffic corridor. In a more abstracted diagram, Unwin idealized this “arrangement of groups of houses at right angles to a road to secure a southern aspect”, with the solar orientation as the primary factor. This diagram described all of the essential aspects of what would later be referred to as *Zeilenbau* planning, an approach that essentially formalized this method into a model.

⁵²⁷ "Introduction to the Second Edition," xviii. Numerous examples of Unwin's lateral approach to the formal and the informal were provided in the manual. A good example is Illus. 170 Leicester Anchor Tenants' Estate.

traffic junctions, Unwin advised applying an entirely different geometry for the building masses, one that defined a “place”.⁵²⁸ A *place* was not to be defined by the geometry of traffic corridors nor did it necessarily imply a “complete enclosure of a continuous ring of buildings”, but instead it called for a “general sense of enclosure from fairly continuous frame of buildings, the breaks in which are small”.⁵²⁹ Here, it was the internal logics of the housing units themselves that provided the material with which to shape place and space. Whether considering the engagement of a site condition, defined by geology or human history, a traffic condition, defined by carts or automobiles, or an urban morphology, defined by the needs of future occupants, Unwin sought to provide the architect tools to engage these issues from the scale of the settlement and the unit, simultaneously.

He would use this unique organizational system, one that bridged between the scale of the unit and the settlement, as a means to critique existing legislation, on economical, social and aesthetic grounds. One of the clearest examples of this argument is included in “two diagrams” comparing the “advantages and disadvantages” of what was possible under By-laws and after the passage of the Town Planning Act.⁵³⁰ (Fig. 52) The first scheme

Here more regular corridors of traffic and regular unit footprints combine into more irregular groups. In many of these examples, Unwin took cues from the many English towns that had developed informally, following the more regular lines of Roman camps, such as Chester, shown on page 4 of the manual.

⁵²⁸ As he explained, the English term “square” was simply a traffic junction, while “the simple French term *place*”, denoted an “enclosed space”, as did similar terms in German and Italian.

⁵²⁹ In one example, Unwin applied a hexagonal frame to a y-intersection, with the two geometries defining the line and the openings respectively, or in Sittean terms, the silhouette and the rhythm. However, Unwin was careful to note that the internal logics of the individual architectural units were also resolved somewhat independently, contributing to the overall “individuality” of the place. In another scheme, titled “group of buildings designed to maintain square roof lines on a curving road”, a particularly informal Y-junction was contrasted with simple rectangular blocks, cut by the traffic corridor and resulting in a complex place. Nevertheless this configuration did not impede on the resolution of the individual architectural units.

⁵³⁰ Illus. 269, 270. Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 350. The same visual argument would be used by Grosvenor Atterbury, in Grosvenor Atterbury, “Model Towns in America,” *Scribner's Magazine* 52 (July 1912). and by Heinrich de Fries Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* (Berlin: Verlag der Bauwelt, 1918). Unwin used the same technique, in more detail, in a subsequent article, Raymond Unwin, *Nothing Gained by Overcrowding! How the Garden City Type of*

showed a “square plot” with a “detached house in the center of it” resulting in a “garden ... cut up into several pieces ... of little practical value” or contribution to “develop any vista”. In the second scheme, the “reverse was the case”, with zero-degree lot line row-houses and deeper parcels, of the same overall area, giving the unit a more substantial garden and allowing for “good vistas” to develop.⁵³¹ Part of the row-house units were pushed back, enclosing a “place”, and demonstrating, according to Unwin, “that from the architectural point of view the grouping of the buildings ... is almost essential for the production of good street pictures”.⁵³² In his discussion of the grouping of buildings, Unwin explained how one could introduce “a few rather large houses” among smaller houses for a “working-class population” so, for example, a “doctor might live among his patients”.⁵³³ However, in order for this rather humble form of social engineering to succeed, it “[would] depend very much on the arrangement” of the basic architectural unit and its grouping on the site.⁵³⁴

Unwin’s manual utilized an architectural language of expression common to English domestic architecture of this period, one that was probably more *picturesque* in its motifs, than in its spatial and temporal organization, as compared to his and Parker’s more

Development May Benefit Both Owner and Occupier. (London: Garden Cities & Town Planning Association, 1912). A very similar format would be used by Le Corbusier to make his argument for *vertical* garden cities, first in *Urbanisme* (1925) and in a later edition of *Vers une Architecture* (1928).

⁵³¹ *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 350.

⁵³² While neither the street nor the building had any of the “wiggle” associated with the landscape school or Sitte’s school, the ensemble constituted what Ruskin called a “snap”, or a break in a sequence. For more on this approach see Ruskin, *The Elements of Drawing: In Three Letters to Beginners*.

⁵³³ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 299.

⁵³⁴ *Ibid.* Unwin was not a trained sociologist, just as Taylor was not a psychologist, with this discussion being less of a fully formed political position than a more disciplinary discussion about unit typologies and urban morphologies. The mixing of classes, or their obliteration, is not the primary goal here; rather it is a consideration of the social ramifications of more quotidian architectural and urban operations. Unwin’s sentiment here, and throughout his manual, is close to the theorization of what Robin Evans has called “architecture’s instrumental role in the formation of everyday events”. For Evans, it “would be foolish to suggest that there is anything in a plan which could compel people to behave in a specific way towards one another, enforcing a day-to-day regime of gregarious sensuality” but it “would be still more foolish, however, to suggest that a plan could not prevent people from behaving in a particular way, or at least hinder them from doing so.” Robin Evans, “Figures, Doors, Passages,” in *Translations from Drawing to Building and Other Essays* (London: Architectural Association London, 1997), 88-89.

reduced, albeit still vernacularizing, architectural work at Hampstead and elsewhere.⁵³⁵ He nevertheless believed that a “new tradition” would certainly emerge, not “accidentally”, as a response to some unconscious zeitgeist, but “consciously”, through the critical engagement of “modern conditions”. It was up to his readers to define this new tradition. While he did not explicitly discuss new fabrication and construction systems, still relying primarily on the conventions of the English building industry in his own work, he warned that one of the most important site conditions that had generated individuality in human settlements throughout history, could no longer be counted on, since these traditions were disappearing, due “partly to the ease of modern long distance carriage”; “Welsh slates” were now being laid in “Whitby” and “Raubon tiles” were being applied in “Rowsley”. This “folly”, one that allowed “cheap transit to reduce (English) towns to one dead level of characterless jumble”⁵³⁶, was also discovered by one of Unwin’s biggest fans in Switzerland, Charles Eduard Jeannerette, on his search for the *ville integrale*, or the “integral village”, a space of synthesis at the settlement, architectural and craft object scales, in the *East*.⁵³⁷ Repeating the English town planner’s own assessment, Le Corbusier would later write that the “peasant on the Danube chose ... decoration” because the “railway brought him wagon-loads full of delicate porcelain, covered with roses as fine as flowers themselves, with

⁵³⁵ Unwin still advocated the “gothic ... style of work” in architecture as the correct language, or at least syntax, for dealing with “irregular sites” since this “picturesque style of architecture”, with its “freedom of treatment in balance and proportion” had “no difficulty” in resolving “clusters ... of buildings, designed without regard to one another” in order to “produce successful groupings”. Although “many classical buildings had been successfully designed for irregular sites”, Unwin felt that this type of architectural expression was more suited for “regular and formal” organizations. Despite this argument, Unwin’s own groupings consisted primarily of “regular cube-shaped mass” units.

⁵³⁶ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 146.

⁵³⁷ Le Corbusier was already familiar with Unwin before he took his journey east in 1911. Le Corbusier, *Journey to the East* (Cambridge: The MIT Press, 2007).

seashells, and leafy tendrils of the brightest gold.”⁵³⁸ While Le Corbusier and others could no longer rely on the preconditions of vernacular culture, Unwin’s manual, which was disconnected from the formal models on which it had been based, provided they did not have to abandon the principles of site design or visual planning, developed during the course of the 19th century. For Le Corbusier and many of his German colleagues, the newly discovered principles with which “engineering (addressed) the problem of form”, explained in the manuals and articles of scientific management, would be combined with a new international industrial vernacular that seemed to be emerging in America, that of *concrete villages*.

Three American Systems of Industrialized Settlement-building, 1908-1918

During the teens, a number of new American journals, such as *Cement Age* and later *Concrete*, as well as a number of book-length publications, such as *The Concrete House and Its Construction* (1912), began to appear in Europe.⁵³⁹ Unlike earlier engineering manuals on concrete construction, these publications offered technical information, as well as a more cultural and aesthetic discussion of concrete building systems, in a visual language more familiar to architects.⁵⁴⁰ Three of the most extensively published systems were the

⁵³⁸ *The Decortative Art of Today* (1998 (1959)), 57-58. Le Corbusier was still thinking about Danubian peasants in 1933, when he included a postcard of this scene in *Ville Radieuse* (1935), 137.

⁵³⁹ *Cement Age* was established in 1904. In 1907, it was combined with *Concrete Engineering*, a more technical journal, and in 1914, it was renamed *Concrete*. The Concrete-Cement Age publishing company was affiliated with the Association of American Portland Cement Manufacturers, who published the *Concrete House and Its Construction* (1912), as well as with the Atlas Portland Cement Company, which published Sanford Thompson’s survey of construction management techniques, *Reinforced Concrete in Factory Construction* (1907). These journals and publications often cited Taylor, Thompson and the Gilbreths. It is also worth noting that the most influential member of the RFG’s board, from the private sector, was Hans Riepert (1874-1939), a high-ranking member of the German Cement Producers Association.

⁵⁴⁰ For example, Le Corbusier certainly found *The Concrete House...* (1912) adequate for his own architectural work, leaving treatises full of charts and formulas to the engineers he collaborated with. For two central technical tasks of architectural production, the preparation of drawings and the coordination of construction, these publications were more than adequate. In a number of cases, they also provided formal models, as I will demonstrate in the next two chapters.

Atterbury System, the Harms and Small System, and the Unit System, all of which were developed between 1909 and 1918, and all of which would be cited, directly or indirectly, by European modernist architects as part of their discussions regarding the application of scientific management to architectural production. I will examine these three systems with four questions in mind: first, what was the architect's role in the development and application of the system, second, how familiar was the system designer with the principles of the laboratory method and the Gilbreths' visualization instruments, third, was Unwin's town planning method applied, and fourth, how influential were these projects during the interwar period.

The Atterbury System, 1908-1918

The Atterbury System, was developed by Grosvenor Atterbury, an American architect, as part of his work on the Forest Hills Gardens 'model village', initiated and financed by the Russell Sage Foundation, a philanthropic institution, on a site in Queens, between 1908 and 1912, and applied to the fabrication and construction of forty units, between 1912 and 1920.⁵⁴¹ (Fig. 53) I will demonstrate that the Atterbury System was only a partial application of the laboratory method to the experimental derivation of a fabrication method for reinforced concrete. The development of this system was limited by a number of factors, first and foremost being the division of labor between Atterbury and Frederick Law Olmstead Jr., the landscape architect town-planner of Forest Hills Gardens,

⁵⁴¹ The most extensive discussion of Atterbury's work is included in Walker, *The Architecture of Grosvenor Atterbury*. Atterbury's work was included in Maurice M. Sloan, *The Concrete House and Its Construction* (Philadelphia: The Association of American Portland Cement Manufacturers, 1912). It was also discussed in a number of issues of *Concrete*, from 1915 until 1918, which I will discuss in this chapter. Martin Wagner also included it in a number of issues of *Wohnungswirtschaft*, between 1924-25. The most insightful and critical assessment of this work is included in Lewis Mumford, "Mass-Production and the Modern House," *The Architectural Record* (1930). It was further elaborated in "Mass Production and the Modern House (Part 2)," *The Architectural Record* (1930).

and the Russell Sage foundation's general lack of support for more dense housing types.⁵⁴² While Atterbury's own articles on the subject show awareness of Unwin's methods⁵⁴³, and not just his built work, he never had the opportunity to apply these methods to this project. (Fig. 54)

Atterbury first demonstrated an interest in developing this system while collaborating with the Carnegie Steel Company on initial designs for his elaborate steel molds.⁵⁴⁴ In 1908, having garnered support from the Russell Sage foundation, he constructed his first experimental prototype, the 64th Street Shack, in New York City. He then followed this initial experiment with two complete, typologically identical two-story houses, constructed in Sewaren, New Jersey. The primary difference between the two were the block sizes; Sewaren House 1 (1909) was constructed of smaller blocks that were 1/3 the height of a full story, and Sewaren House 2 (1910), was constructed of full story

⁵⁴² The Russell Sage Foundation was founded in 1907 to investigate and promote affordable housing. The board of directors, which oversaw the Sage Foundation Homes Company that developed Forest Hills Gardens, were directly responsible for selecting the models for the 'model town', including Port Sunlight, Letchworth Garden City, Hampstead Garden Suburb, Hellerau *Gartenstadt* (still primarily on paper in 1909), as well as a series of older settlements in Darmstadt, Frankfurt and Hamburg. They designated Frederick Law Olmstead Jr., as town planner before hiring Atterbury, a Beaux-Arts trained architect who had gained his fame building mansions for the board's peers. The board showed resistance towards multi-unit types, and instead favored the single family and duplex structures that marked earlier suburbs like Riverside Park. Nevertheless, the Foundation was crucial in funding Atterbury's costly experiments investigating the fabrication and montage of concrete panels.

⁵⁴³ Atterbury, "Model Towns in America." Atterbury's studies of architectural grouping techniques, on pages 27-29, show a clear familiarity with Unwin's methods, and not only the formal models of Hampstead, or Hellerau, from which his architectural expression was partially based. Partially because of the limited scale of Atterbury's applications of his panelized system and partially because of his own lack of training in visual planning, his Groups at Forest Hills never fully achieved the spatial complexity of those at Hampstead or Hellerau. A set of diagrams on pages 30 and 31, which demonstrated how a communal space could be introduced into an existing block, while still maintaining a comparable number of sellable parcels, also reflects the specific techniques discussed in Unwin, *Nothing Gained by Overcrowding! How the Garden City Type of Development May Benefit Both Owner and Occupier*. These were also included in the 1909 manual.

⁵⁴⁴ Walker, *The Architecture of Grosvenor Atterbury*, 254-55. Walker also accurately points out that John Conzelman had patented an early iteration of his concrete system at this time, suggesting that it might have influenced Atterbury. A more likely source, not discussed by Walker is the earlier work of Norman Shaw and Ernest Newton, based on a system developed by W. Lascelles, published in Ernest Newton Norman Shaw, *Sketches for Cottages, Country Residences, and Other Buildings: Designed to Be Constructed in the Patent Cement Slab System of W. Lascelles* (London: B T Batsford, 1878). Atterbury's own work resembles this work, both in its internal planning and expression.

reinforced concrete panels, utilizing the same system for its floors and roof. Sewaren House 2, having used highly precise machined steel molds, which required significant mechanization and factory-like conditions for fabrication, as well as a construction plant consisting of temporary rails and a heavy-weight crane on site, reflected all of the basic characteristics of the mature Atterbury System.⁵⁴⁵ (Fig. 55) As his first filed patent, the “Apparatus for Molding and Casting” (1909), clearly indicated, Atterbury focused his work on further refining a number the materials and methods of existing systems.⁵⁴⁶ (Fig. 56)

In 1911, Atterbury was allotted two sites by Olmstead at Forest Hills Gardens to demonstrate the applicability of his system to multi-unit housing.⁵⁴⁷ Two structures of fourteen units were constructed around the same time, one of conventional materials and the other, Group II, of precast concrete panels, fabricated near the site in a shop erected specifically for this purpose.⁵⁴⁸ Limited in his role by the division and hierarchy of labor, as

⁵⁴⁵ The Sewaren House 2 was published in 1912 in the *Concrete House and Its Construction*. Atterbury lectured on this work at the 5th National Conference on Housing in 1916. Conzelman would lecture there in 1917. Atterbury published his system, including data generated by the experimental work, between 1909 and 1912, in Grosvenor Atterbury, *The Manufacture of Standardized Houses: A New Industry* (New York: Standardized Housing Corporation, 1918). I have used this material to inform my assessment. The data reflects Atterbury’s focus on the experimental derivation of a fabrication system, with little discussion as to its construction. Russell Sage’s support also allowed him to ignore the high capital costs of his elaborate steel molds and heavy cranes, the data on which has been omitted from published data visualizations. The visualizations themselves also show no knowledge of Gilbreth’s visualization theory, with the exception of the photographs themselves, which could be called progress photos. However, their primary use was for documentation rather than management, an application that would have been impossible without a more extensive use of Gilbreth’s graphic projection instruments.

⁵⁴⁶ Apparatus for Molding or Casting. USA, Feb. 15, 1916 (Application Filed Oct. 8, 1909). The patent shows just how intricate Atterbury’s molds were, requiring significant investment, skill and mechanization to fabricate, and therefore requiring mass production to be economically viable. In contrast, Conzelman’s first patent, applied for on January 9, 1909, and patented June 21, required minimal mechanization for casting. Atterbury continued to focus primarily on off-site fabrication in his work throughout this period, as evidenced by a later patent, Process of and Apparatus for Making Concrete Slabs. USA, Jan. 6, 1920 (Mar. 15, 1919).

⁵⁴⁷ There is no indication that Atterbury planned to apply the laboratory method to this work.

⁵⁴⁸ Included in Atterbury, *The Manufacture of Standardized Houses: A New Industry*. These would be published in *Industrial Houses of Concrete and Stucco: A Survey of the Principal Types and Groups of Permanently Constructed Industrial Houses*, (New York: The Atlas Portland Cement Company, 1918)., Frederick Squires, "Precast Unit Houses at Forest Hills Gardens," in *Concrete Houses: How They Were Built* (Detroit: Concrete Age, 1920)., and in Martin Wagner, "Der Rationelle Wohnungsbau," *Wohnungswirtschaft* 1, no. 17/18 (1. Dezember 1924).

well as a lack of training in settlement design, implementation of the Atterbury System never exceeded the architectural group scale. In the first implementation, Atterbury relied on a hexagonal open-court scheme.⁵⁴⁹ (Fig. 57) Half of the hexagon was made up of ten identical 13' wide and 40' deep two story row house units, ended and hinged with four identical single-family units. The hexagonal arrangement seemed to benefit the organization of the construction plant, allowing the rail on which the crane moved to follow the geometry and providing a small depot space where the panels could be delivered by truck. In ideal conditions, a single row house, which consisted of 140 panels from six different molds, could be completed in nine days, after which the basic utilities and any interior plasterwork could be applied.⁵⁵⁰ While the entire structure was completed in 1912 and settled in 1913, both the multi-unit typology and the Atterbury System were put on hold until 1918, when Atterbury was tasked to design model groups of single-family and detached units, in parcels predetermined by Olmstead's more *wiggly* town plan. Given a second chance to demonstrate the feasibility of his system, Atterbury constructed two nearly identical "groups", really slabs, of eight nearly identical row-house units, Group 48 and 49, very similar to the much earlier schemes designed by Norman Shaw, following a Concrete Slab System developed by W. H. Lascelles.⁵⁵¹ (Fig. 58) The units were shallower in

⁵⁴⁹ Atterbury, *The Manufacture of Standardized Houses: A New Industry*, 23. This scheme was informed by one of Unwin's organizational schemes for an "irregular road junction where the buildings are planned to finish square with each road in groups, forming a hexagonal figure." Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 343. Muthesius used this scheme at Hellerau, and included it in Hermann Muthesius, *Landhäuser* (Munich: F. Bruckman, 1912), 178. In both of these cases, a more muted building mass was contrasted with a much more complex spatial arrangement, while in Atterbury's case, a more singular, tectonically complex object sat more statically on a single parcel.

⁵⁵⁰ Walker, *The Architecture of Grosvenor Atterbury*, 176-77.

⁵⁵¹ Atterbury, *The Manufacture of Standardized Houses: A New Industry*, 30. This iteration also closely resembled a number of the schemes included in Norman Shaw, *Sketches for Cottages, Country Residences, and Other Buildings: Designed to Be Constructed in the Patent Cement Slab System of W. Lascelles*. As Walter Creese has astutely pointed out, "the Shavian country house had become the multiplex" and the "superhouse had (become) equated with the super block", at Port Sunlight, a decade earlier. Creese, *The Search for*

depth and wider in frontage than Group II, but were aligned in a single three-story linear volume. This was to be the last built example of Atterbury's System.

Ironically, the same patronage that had supported Atterbury's costly experiments in fabrication had also limited his opportunity to further evolve and standardize them, through construction and occupation. As the architect concluded in 1912, "no experiment or demonstration should be made in a 'model town' such that could only be duplicated with the aid of philanthropy, charity, or paternalism, or..., as is the case in the demonstration by the Russell Sage Foundation at Forest Hills."⁵⁵² Without specifically quoting Frederick Taylor, Atterbury repeated the key difference between the "laboratory idea" applied to a functioning industrial plant operating in a more-or-less managed market economy and that of a true laboratory, where materials and methods are tested in a socio-cultural vacuum. While Atterbury's first three structures and, to a lesser degree, Group II, did engage in a kind of experimental derivation of standard fabrication and assembly techniques, the parameters did not actually consider cost, and the last three structures were primarily applications of these standards. In spite of his own call that "the model town must be considered, organized and developed on a business basis", his data mappings, which primarily consisted of idealized material and labor costs, indicate that the instruments of scientific management were not wholly used.⁵⁵³ His later writings lacked this more critical assessment, demonstrating instead the more typical faith in mechanization that later

Environment: The Garden City, before and After, 122. In fact, Shaw had already translated the country house into a *slab* in 1878.

⁵⁵² Atterbury, "Model Towns in America," 32.

⁵⁵³ *Ibid.* As the note on his published data indicated, "unit costs for constructional shell in cents per cubic foot of house contents giving net cost of labor and material" was "exclusive of excavation and footings, and without any overhead for fixed charges", not to mention the cost of land itself. His data did show that between 1910 and 1913, the same crew was able to increase efficiency, through serial work. This work was only studied through time studies, not motions studied. *The Manufacture of Standardized Houses: A New Industry*, 13.

scholars would associate with the modern movement as a whole, claiming that the “substitution of machinery for the human mechanic” would ensure a more economical housing delivery system, despite his own experiences.⁵⁵⁴

Initial reviews of Group II accepted Atterbury’s aesthetic and economic claims, calling it “a scene for picturesqueness not equaled anywhere in America” and praising the architect for his “artistic use of concrete, unequaled in the world.”⁵⁵⁵ The reviewer even claimed that, “in spite of adverse conditions, the commercial possibility has been demonstrated, so as to be available in further undertakings which are of sufficient magnitude to warrant the “wholesale” methods involved”.⁵⁵⁶ He glossed over the Achilles heel of this and all later large-panel precast systems, namely the thermal and hydro enclosure of the system, explaining that the “only vulnerable point is the joints”. In fact, they were presented as an aesthetic advantage, the fulfillment of the “gospel of architecture”, since “every floor”, and therefore every joint, “shows through and that every feature of construction writes itself on the outside of the building so (anyone) may read” its construct.⁵⁵⁷ Wagner, Taut and May would be less complimentary, during the twenties, but they nevertheless found the project an important early example of industrialized housing delivery.⁵⁵⁸

A more critical assessment of the Atterbury System came from Lewis Mumford in 1930. Mumford correctly pointed out that the architect’s key issue in the twentieth century

⁵⁵⁴ As William Kent, a member of the Gilbreth consulting team explained in 1913, scientific management was not simply defined by the application of mechanization; rather, it often included the decision of whether or not to introduce a particularly costly technological innovation. William Kent, "Investigating an Industry: General Considerations," *Industrial Engineering and the Engineering Digest* XIII, no. 2 (February, 1913).

⁵⁵⁵ Squires, "Precast Unit Houses at Forest Hills Gardens."

⁵⁵⁶ *Ibid.*

⁵⁵⁷ *Ibid.*

⁵⁵⁸ Wagner, "Der Rationelle Wohnungsbau." May, "Mechanisierung Des Wohnungsbaues."

was how the discipline would respond to the “radical change ... [which has] passed almost unnoticed” by architects; that “manufacture ha[d] step by step taken the place of the art of building.”⁵⁵⁹ Even the architects, like Atterbury, who first designed “industrial villages” had focused on the “shell of the building”, despite the fact that the principles of industrial organization would have more significant impacts in other areas of building. Using his own data graphics, he showed that the “largest element in cost” was the cost of “money”, and therefore time, as well as the cost of land and utilities.⁵⁶⁰ (Fig. 59) It was therefore, “for the lack of proper cost accounting our experimental architects have been butting their heads against this solid wall for years.”⁵⁶¹ He also cautioned against “premature standardization”, the definition of a standard that had not been adequately tested in a socio-economic context.⁵⁶² To further his argument, Mumford turned to Forest Hills, “the architect’s attempt to individualize an industrial village”, “an attempt that failed.” While the “middle classes” occupied the recently completed development, it was the “poorer man” who resided in the “jerry-building” seen all around the *model town*.⁵⁶³ He advised the architect to critically examine a “sector of Brooklyn”, an industrial vernacular “(o)n the way toward standardization”.⁵⁶⁴ To avoid being entirely replaced by the jerry-builder, Mumford argued, the architect would have to pay similar attention to the “great underground root mechanism” of infrastructure servicing this fabric.⁵⁶⁵ The problem of modern housing would be defined at this new scale, that of the pre-modern urban unit, the settlement.

⁵⁵⁹ Mumford, "Mass-Production and the Modern House," 13.

⁵⁶⁰ Ibid., 17.

⁵⁶¹ Ibid., 18.

⁵⁶² Ibid., 20.

⁵⁶³ Ibid., 15.

⁵⁶⁴ Ibid., 14.

⁵⁶⁵ Ibid. He would provide a number of examples of industrial villages from the teens in the follow up to this article, "Mass Production and the Modern House (Part 2)." These examples all drew on Unwin’s principles.

The Harms and Small System, 1908-1920

The Harms and Small System was developed by two American engineers, George Small and Henry Harms, between 1908 and 1916, and differed from the Atterbury and Unit Systems, in two important ways: first, it was primarily a poured in place system, not a precast panel system, and second, it was primarily developed in Europe, not in the United States. Unlike Atterbury, Harms and Small experimentally derived and standardized their system through a series of projects that utilized instruments, directly attributable to Gilbreth, to manage the engineering of men and capital, as well as materials and the forces of nature. This occurred first in, more controlled, architectural scaled projects, and later in, more complex, commercial settlement-building work, which included the delivery of hundreds of units. Harms and Small initially enjoyed a fruitful collaboration with architects in Holland, where they *defined their standard* system at the unit scale, but were less satisfied with the architect-town planners with whom they worked with in France, on the further standardization of their system through the construction of houses in series, at the scale of the settlement.

The development of the Harms Small System began when the two young engineers were employed by Thomas Edison to resolve what he felt were the minor practical details of his "Process of Constructing Concrete Buildings" in 1907. (Fig. 60) As the 1908 patent clearly demonstrated, Edison's theoretically viable system consisted of a number of unresolvable problems.⁵⁶⁶ First, and foremost, his system consisted of a building-sized steel

⁵⁶⁶ T. A. Edison. Process of Constructing Concrete Buildings USA, March 13, 1917 (Application Filed Aug. 13, 1908. The patent was published in Peter Christensen Barry Bergdoll, "Home Delivery: Fabricating the Modern Dwelling," ed. MoMA (New York: MoMA, 2008). The authors of this catalog mistakenly attributed Edison's patent to a housing settlement in Phillipsburg, New Jersey. In fact, they were designed by a team of engineers working for the Ingersoll-Rand Company, the producers of the cement gun, following a technological and aesthetic approach attributable to Harms and Small, not Edison, between 1917 and 1919. "Ingersoll Type

mold, complete with floors and a roof, whose fabrication, erection on-site, and dismantling would prove impossible. Second, the system depended on significant on-site mechanization, and energy, to pump concrete to the top of the mold, like *milk pouring into a bottle* before the concrete could fill all of the narrow cavities, constricted further by reinforcing.⁵⁶⁷ Third, the approach was constituted of an entirely closed system, with no design flexibility and requiring significant upfront investment.⁵⁶⁸ Edison's relationship and contract with the engineers had ended by July 1909⁵⁶⁹, and by July 10, 1909 they had filed their own patent for a "single pour" house.⁵⁷⁰ (Fig. 61)

Between the application for the patent in 1909 and its approval in 1916, Harms and Small moved to Europe, where their work directed the system further away from Edison's and their own earlier patents. The first *experiment*, at the architectural scale, was conducted in Santpoort, Holland in 1911, and a second one in St. Denis, France in 1912.⁵⁷¹ These projects, referred to by the authors as "experiments and a training school", were followed by the "industrial application", or standardization, of the system, through two

Houses at Phillipsburg and Union," *Concrete* (Jan 1919). "Ingersoll Type Houses at Phillipsburg and Union," *Concrete* (Aug 1919). "Ingersoll Type Houses at Phillipsburg and Union," in *Concrete Houses: How They Were Built* (Detroit: Concrete-Cement Age, 1920). Here, Unwin's town planning principles were also applied.

⁵⁶⁷ As Muthesius and Le Corbusier later observed in Hermann Muthesius, "Der Typenbau (Type Building)," in *Kleinhaus Und Kleinsiedlung* (Munich: F. Bruckmann A.-G., 1918). and in Le Corbusier, "Maisons En Série," *L'Esprit Nouveau* 13(1922). Muthesius explicitly mentioned Edison and Le Corbusier was almost certainly familiar with the work of Harms and Small in France. He was also probably familiar with the Ingersoll Settlement in New Jersey, images of which were often included in cement gun advertising.

⁵⁶⁸ As Tom Peters has accurately explained, the system was "doomed for failure", as its "extreme inflexibility condemned it, much like the room-sized French and Russian systems half a century later". Peters, *Building the Nineteenth Century:*, 381-82.

⁵⁶⁹ A 1909 issue of *Cement Age* reported that: "Mr. Edison's first idea was a two-family house, designs of which were made by a New York architect, and considerable work was done on the patterns for the molds. The idea was abandoned. George E. Small and Henry J. Harms, Jr., the engineers engaged by Mr. Edison to design the molds, made the necessary experiments. ... and that a house built of stone, according to this design, would cost between \$20,000 and \$30,000."

⁵⁷⁰ H. J. Harms & G. E. Small. Molding Apparatus for Houses. USA, June 20, 1916 (Application Filed July 10, 1909). Whether or not motion study was applied to this early patent is unclear. Even this significantly transformed variant of Edison's system proved to be unbuildable.

⁵⁷¹ The Dutch work was published in George E. Small, "Poured Houses in Holland," *Cement Age - Concrete Engineering* XIV, no. 2 (February, 1912).

settlement-scale projects started during the early summer of 1914, immediately before the outbreak of the Great War.⁵⁷² The construction of the first settlement, which consisted of 228 units for *Crepuy et Fils* Co. near Lille, ended after a German drive through the city in October, 1918. As a result, the second settlement of 114 units for the *Cie. des Produits Chimiques d'Alais et de Cammargue* in Salindres, France, served as the key site for the system's translation from the scale of an architectural to an urban unit, at least in terms of production, completed in 1916.⁵⁷³ After Salindres, the system was applied in a series of smaller commissions throughout France.⁵⁷⁴

Harms, a self-described “two-fisted Yankee engineer”, explained that the motivation for this French work, much of which was conducted “under war conditions”, was “because America was not yet ready” to accept “concrete houses”.⁵⁷⁵ Without these *war conditions*, it seems likely that French citizens, even architects, would not have been either. In Europe, Harms found that “(c)oncrete is not yet so general a building material” as it was in America, in terms of “roads and sidewalks”, and particularly in housing, where much of the dwellings of northern France were built out of brick and block and in the south out of “poor limestone, laid in cement and mortar”.⁵⁷⁶ The engineering duo saw their wartime work as preparation for the massive rebuilding effort that would be required throughout Europe after the Great War.

⁵⁷² Henry J Harms, "Building Concrete Industrial Houses by Harms · System: Second Article Describes Layout of Work, Equipment and Methods Used," *Concrete* 12, no. 2 (February, 1918). Reproduced in "Building Concrete Industrial Houses by Harms System in France," in *Concrete Houses: How They Were Built*, ed. Harvey Whipple (Detroit: Concrete-Cement Age Publishing Co., 1920 [1918]).

⁵⁷³ "Building Concrete Industrial Houses by Harms System in France." This chapter of *Concrete Houses* included the complete articles on Harms and Small's work from 1912 until 1920.

⁵⁷⁴ 52 units constructed in Basses-Indres (1919), 200 units in St. Aubin (1920), as well as a small but significant commission for 40 structures for the St. Gobain glass fabricators, started in 1920. *Ibid.*

⁵⁷⁵ *Ibid.*

⁵⁷⁶ While Harms acknowledged that the typical wood construction favored in American mass housing would probably be cheaper than his system, it was “absolutely prohibited for dwellings in most European countries”.

The basic characteristics of the Harms Small System were already visible in the 1909 patent. Instead of a singular massive steel mold, the system relied on smaller “interchangeable” molds, which were 16 x 32 inches in size, 75 pounds in weight and could be combined to form an “unlimited variety of styles and sizes of structures.”⁵⁷⁷ Like the Edison patent and the Atterbury system, the system was planned to be fabricated out of steel, but the engineers soon turned to cast iron for most of the molds, with precast windowsills being the exception. The most significant change, one that Harms and Small somewhat grudgingly accepted, was the replacement of molds for the floors and roof with precast elements, cast with the same molds but set with the molds for the vertical walls, to form a monolithic structure. In their first article on the system in 1912, they set out to correct the “indiscriminate and indefinite information” regarding what actually constituted a “poured house”, referring to the press that Edison had already received for the idea, which neither he nor his former assistants had actually resolved.⁵⁷⁸ They defined such a structure as being “poured as a monolith with one pouring”, but adding that the “floors and steps” of this structure could be made in “two ways”, by either “pouring (or) by casting in advance and placing during the erection of the molds.”⁵⁷⁹ As late as 1920, they still dreamed of a structure cast “in one single pouring” but explained that “while (it was) possible” to do such a thing, it would require one to place “molds underneath and above”, a process that would “be slow and ... would require a very solid shoring”.⁵⁸⁰ Furthermore, the “dismantling of the floors could not be done at the same time as the walls”, adding fourteen

⁵⁷⁷ Small, "Poured Houses in Holland," 63.

⁵⁷⁸ *Ibid.*, 67.

⁵⁷⁹ *Ibid.*

⁵⁸⁰ Harvey Whipple and C. D. Gilbert, "Concrete Houses," in *Concrete Houses: How They Were Built* (Detroit: Concrete Age, 1920), 60.

days to a process that they had truly shortened to 36 to 48 hours.⁵⁸¹ Such a process would require a greater number of molds, driving up the initial costs, further validating the use of the hybrid approach.

As the publication of their first ‘poured’ house in 1912 demonstrated, this system was developed and disseminated using motion study tools directly attributable to Gilbreth. (Fig. 62) A series of “construction views”⁵⁸², carefully timed and framed progress photos (a term they would later use), had been used to manage, analyze and disseminate the complex assembly, casting and disassembly process of the molds, reinforcing and precast elements, one floor at a time. The molds were also designed to serve as scaffolding, allowing for the manual delivery of the concrete mix, which was hoisted up to a platform and emptied directly into the molds. Ultimately, the entire process for a single, two-story structure lasted six hours.

Harms and Small’s distance from America, as well as their anxiousness about their patent-pending drove them to publish their work extensively, resulting in a detailed account of their experimentation and standardization process. At a time when it was still unusual for contracting engineers to share their cost data, viewing “this information” as somewhat of a “trade secret”, Harms and Small gladly disseminated “accounts of the work” through “accurate and practical data on costs”, as well as “the difficulties encountered and how they were overcome.”⁵⁸³ Unlike many of their peers at this time, they fully embraced the full visual spectrum, including “photographs, taken at intervals during the progress of

⁵⁸¹ Ibid.

⁵⁸² Small, "Poured Houses in Holland."

⁵⁸³ Their work prompted an article on the subject by the editors of *Cement Age* in 1912. Pg. 67

the work”, and “plans and elevations” developed by more or less cooperative architects.⁵⁸⁴ They also presented the work through the discourse of the laboratory method, explaining that the “first houses were built” to demonstrate the “possibility to pour or cast a complete house in continuous operation”.⁵⁸⁵ Initial experiments provided the “necessary data” using a space-time coefficient of meters/hours for planning and managing the “industrial applications” of the system to serial building in settlements.⁵⁸⁶ At Salindres, for example, nineteen of the fifty seven structures served to experimentally derive further data through “time studies”, actually studies and documents of motion, at the scale of an urban group arranged around a single street in that settlement.⁵⁸⁷

In their first architectural-scale experiment, the engineers reported a successful collaboration with two Dutch architects, a H. Hana, who prepared the necessary documents, and Hendrik Berlage, who consulted on the overall aesthetic and tectonic expression of the system.⁵⁸⁸ Harms himself was an “advocate of absolutely flat roofs” for these structures, inserting hollow roof beams to “create forced ventilation” and finishing the surface with an early rubberized treatment.⁵⁸⁹ (Fig. 63) The engineers also praised the

⁵⁸⁴ Small, "Poured Houses in Holland," 63. In the same issue, the editors first discussed progress photos, "Moving Pictures," *ibid.*

⁵⁸⁵ Harms, "Building Concrete Industrial Houses by Harms System in France," 56.

⁵⁸⁶ *Ibid.*

⁵⁸⁷ *Ibid.* Walter Gropius would use a very similar approach, at Dessau, a decade later.

⁵⁸⁸ There is relatively little documentation of this interesting collaboration. Berlage shared an interest similar to that of Muthesius, in the evolution of types, as observed in vernacular architecture and often used the Dutch equivalent of the German term *Sachlichkeit, zakelijkheid*. As was the case in Germany, this concept was not uniformly embraced, even by modern architects, as has been shown in Helen Searling, "Betondorp: Amsterdam's Concrete Garden Suburb," *Assemblage* 3(1987): 119. Searling also incorrectly attributes this project to Edison, in a footnote on page 137. Nevertheless, she accurately points out that this was the first reinforced concrete house in the Netherlands. A Dutch source from the same year ignores Edison, Harms and Small and H. Hana, who was probably the actual architect of the project, giving Berlage, who probably only reviewed the drawings, full credit for this “experiment”. Boersma, *Betondorp: Ontwerp, Maatschappij, Techniek*, 20,23.

⁵⁸⁹ Harms, "Building Concrete Industrial Houses by Harms System in France," 60. This detail first emerged during the laboratory work at Salindres, it was not included in the Dutch work.

“new and fascinating ornamentation” of their “new mode of building”, referring to the patterns left by cast iron molds, one that was “quite its own, making unnecessary the addition of any superfluous” additions and saving significant time and cost in terms of finishes.⁵⁹⁰ (Fig. 64) Harms and Small found the French architects and clients less willing to “take full advantage of the aesthetic possibilities that lie in concrete industrial houses,” and felt that different unit designs, more in tune with the logics of their system, would have “secured even better (aesthetic) results and no increase in cost.”⁵⁹¹ The “idea of building dwellings in series, like any commercial product”, but on the site rather than in a factory, seems to have “horrified” architects and clients alike.⁵⁹² While their French collaborator’s lack of willingness to engage the “new mode of building” primarily irked Harms and Small aesthetically⁵⁹³, their insistence on a settlement design methodology that ignored existing site conditions, as well as the fabrication requirements of their temporary plant, proved an economical, as well as aesthetic problem.

At Salindres, for example, the “general layout of the (worker’s) city, as well as the designs of the houses, furnished by the client”, not only prevented a “picturesque whole” from being “obtained without extra expense”, but the rationalistic trellis grid created a

⁵⁹⁰ Ibid., 63. Whether this was the *engineer’s aesthetic* or that of Berlage is not clear. Their French partners did not find it appropriate.

⁵⁹¹ "Concrete Dwellings in France: Six Successful Industrial Housing Enterprises the Basis of Full Cost and Construction Data," *Concrete* 12, no. 1 (January 1918): 16.

⁵⁹² Ibid.

⁵⁹³ Harms went so far as to quote an article on the subject published by a French architect, Vietor Isouard, with whom he had not collaborated: “One notices immediately the absence of the architect in this conception—the engineer and the builder have been only preoccupied with the proper alignment, with the construction of houses with truly square corners, of symmetrical streets.... It is evident that with only the flat roof, the monotony would result; but the flat roof is not all obligatory, it is easy to make sloping roofs. This is evidently but a timid experience, the application of which could be more daring.” “What French Industrial Dwellings Cost,” *Concrete* 12, no. 3 (March, 1918): 81.

number of issues in terms of the routing and scheduling of serial production.⁵⁹⁴ (Fig. 65)

The general location of the *cité ouvrières* was determined by the position of a road, leading to Salindres, and the proximity to a rail line, which could feasibly deliver the temporary plant and significant amounts of cast iron molds that constituted Harms and Small's operation. In sharp contrast to the town plan, the American engineers arranged their temporary construction plant, which included portable tracks leading from the freight station, on the edge of the site, to the portable stone crushing and cement mixing plant, at a high point of the site, whose "steep grade" had generally been ignored by the settlement plan, both in terms of traffic and building placement.⁵⁹⁵ While the three basic types used at Salindres were similar in basic expression to the earlier Dutch work, albeit now with added decorative motifs, the distribution of the three types, determined by the local architects with little or no consultation with the engineers, made the sequencing of production more difficult. As a means to inscribe in time the logics of site and fabrication that had been spatially ignored by the settlement scheme, the engineers had hoped to move through the grid, "all the time working down and toward the freight station, the point where (their) plant and material arrived and from which it later (would) leave".⁵⁹⁶ However, a number of delays, first in document approvals, then in the delivery of the molds and finally in raw materials for the concrete made even this already compromised organizational approach impossible. Nevertheless, at the street scale, Harms and Small developed a "program"

⁵⁹⁴ Ibid. The general layout is in "Building Concrete Industrial Houses by Harms System in France," 57. The location of the temporary construction plant does not seem to have had a major impact on the town plan.

⁵⁹⁵ Ibid. Harms and Small explained that the temporary "(p)lant ... arrived at the freight station shown on the plan, from which we had laid portable tracks, as shown, track 1 having a steep grade. (French railroad regulation prevented us from discharging across the tracks.) We received our stone from the factory over track No.2, from a quarry in the neighborhood supplying gas ovens; they sent us all the undersized stone (below (2%). We crushed it to 1", using the crusher run and adding necessary river sand. We generally added gravel, because the quarry did not supply us fast enough with the necessary stone."

⁵⁹⁶ Ibid. 58.

taking advantage of the repetitive units and streets that they had to work with, with temporary tracks for a mechanically assisted mobile concrete pourer placed where the actual streets would later be fabricated. (Fig. 66, Fig. 67) Instead of erecting two floors before pouring concrete, the serial nature of the work suggested that all of the ground floors on a single street be erected first, with the necessary prefabricated elements inserted before the concrete was poured, and while the second set of molds, for the upper floor, were assembled. The scale of the operation also now warranted the establishment of a small plant, on site, for the fabrication of the floor beams and hollow roof beams. (Fig. 68) Like Gilbreth, Harms and Small, working on multiple projects from a central office in Paris, relied on photographs of the work, “taken one week apart”, which once the standard methods were established, showed a rate of production of two houses per week.

The Harms and Small system provides an interesting case study for a number of reasons. First and foremost, it demonstrates the varying results achieved when conducting experiments negotiating engineering materials and forces of nature within an actual laboratory, such as Edison Labs, versus within the actual space of production, which was in this case a construction site, as advocated for by Taylor’s laboratory method. It also demonstrates the use of the Gilbreths’ approach to transform Edison’s failed system, one that had relied primarily on mechanization, to the Harms Small System, which utilized simpler molds, required less mechanization, and focused on increased organization through better visualization and projection instruments. At the architectural scale, there is some indication that the *Sachlichkeit* theories of Harms and Small’s Dutch partners did help the system’s evolution. Using the next case study, the Unit System, I will argue that had

Unwin's settlement design techniques been utilized, a more economically efficient and aesthetically complex settlement at Salindres may have been the result.

The Unit System, 1908-1919

The Unit System was developed by John Conzelman, the chief engineer of the Unit Construction Company, (St. Louis, Missouri) through "experience gained during ... ten years (of) construction of factory buildings, warehouses, elevators, railroad structures, and practically all types of reinforced concrete structures, all of which were constructed by unit method."⁵⁹⁷ The astonishing number of patents filled between 1909 and 1912, show a focus on "concrete construction", informed first and foremost by the design and assembly of infrastructure.⁵⁹⁸ (Fig. 69) As a result, fabrication was organized to be as simple and low-tech as possible, requiring minimal formwork, no expensive steel molds, and capable of being entirely produced on site with much of the conventional mechanization already common in road construction.⁵⁹⁹ Just as his numerous patents suggest, Conzelman's methods were truly developed through a process of experimentation and standardization, within the space of production, which was in this case the construction site. In addition to this laboratory method-like approach, Conzelman's work demonstrated a specific

⁵⁹⁷ Conzelman, "Ready-Made Houses," 86. The Unit Construction Co. primarily focused its initial interests on transportation infrastructure, shifting from site cast to precast concrete, before then applying that same approach to industrial plants, and eventually a housing settlement in Youngstown, Ohio (1917-1919). Like Gilbreth's tenure as head of a construction company, Conzelman's leading position in the Unit Construction Company allowed him the agency to experiment, but also exposed him to risk, unlike Atterbury and most consulting engineers.

⁵⁹⁸ The first patent was applied for on January 9, 1909 (Patented June 21, 1910), the same year that Atterbury filed his first patent, and the definitive one, later used at Youngstown was applied for on February 27, 1910 and patented July 2, 1912, when Atterbury's Group II was constructed.

⁵⁹⁹ Conzelman applied for and successfully received an impressive number of patents, including "Concrete Construction" (1909/1910), "Concrete Construction" (1910/1911), "Concrete Construction" (1910/1912), "System of Reinforcement For Concrete Slab" (1911/12), "Wall Construction" (1911/12), "Double Wall Construction" (1911/12), "Wall Construction" (1912/13), "Concrete Roof Construction" (1912, 1916", even a patent for a complete grain silo (1911/12). Here, the trial and error, *laboratory method* nature of his work is also visible, with each patent reflecting a continual process of experimentation and standardization, in the field.

knowledge of Gilbreth's visualization approach, which he began lecture on, starting in 1915.⁶⁰⁰

In early 1917, the Unit Construction Company was hired by the Buckeye Land Co., a subsidiary of the Youngstown Sheet & Tube Co., to construct as many as 280 units of housing in a "colony" near their plant in East Youngstown, Ohio. Conzelman then hired Herding & Boyd Architects and Town Planners to collaborate on this project, both at the scale of the town plan and the unit design. While much of the system had already been defined through work on infrastructure, Conzelman and the Unit System proved flexible in transforming and adapting to this new task. Although it was only a few months after the first experimental units were set, both the scale of the project and Conzelman's already established reputation resulted in his invitation to speak at the *Sixth National Conference on Housing* in October 1917.⁶⁰¹ In his introduction, Conzelman defined the issue as "giving the workingman suitable accommodations with wholesome surroundings, and at a price which he can afford to pay."⁶⁰² Echoing the discourse of contemporary industry, he emphasized organization over mechanization, discussing the importance of the "time element", not only in terms of the efficiency of production but also in the planned longevity of the product, or its "upkeep".⁶⁰³ Despite his system's roots in a variety of design problems, and probably because of that, Conzelman insisted that "no one type of construction or one general plan"

⁶⁰⁰ In October of 1915, at a meeting of the Engineers Club of St. Louis, Conzelman presented his work through the assistance of "motion pictures", stereoscopic progress photos and motion studies accompanied by real cost data. During the course of the meeting, where Gilbreth's and Taylor and Thompson's manuals on concrete construction were also referenced, the Club voted on making a major investment in a new lantern slide projector, as well as a film projector, so that other members might share their work in this manner. Joseph W Peters, "The Engineers' Club of St. Louis," *Journal of the Association of Engineering Societies* 55, no. 3 (October, 1915).

⁶⁰¹ Unlike Atterbury, who lectured at the same event in 1916, after the completion of only 14 units under the benevolent patronage of Russell Sage, Conzelman's lecture demonstrated a much clearer understanding of the issues at hand and produced a set of theories that were actually put into practice between 1917 and 1919.

⁶⁰² Conzelman, "Ready-Made Houses," 81.

⁶⁰³ Ibid.

should be assumed to “meet all requirements” but that instead, “local problems”, in this case the “type of house”, as well as “the size, arrangement, and number of rooms, the conveniences to be installed” and the “materials” used should all be “solved with reference to each individual case”.⁶⁰⁴ The title of Conzelman’s lecture, “ready-made houses”, referred to the construct of “houses ... built of standardized parts”.⁶⁰⁵ While the notion of having these parts fabricated in a factory prior to being “shipped to the building site” and erected did present a kind of “ideal ... (u)nder proper conditions”, those conditions did not yet exist.⁶⁰⁶ Therefore the methods had not yet “been developed sufficiently” or “standardized to an extent as to warrant the erection of factories for this purpose.”⁶⁰⁷ It was important to first “gain the necessary knowledge through ... actual construction before attempting the factory plan,” since only after building a “number of colonies” would one “know enough to start factories.”⁶⁰⁸ While this approach would not be entirely commercially viable until such a time, it nevertheless constituted a necessary process of investigation.

Not only was the erection, or even the design, of factories for ready-made houses a form of *premature standardization*, Conzelman explained that there would always be disadvantages to such an approach. The significant financial investment of a fixed industrial plant would implicate that particular district to provide “sufficient demand”.

Transportation limited the “size and weight of the units”, just as a fixed system provided a “cramping influence on the general plan” of a building, an infrastructure or an entire

⁶⁰⁴ Ibid., 83. His discussion is reminiscent of Unwin’s manual. Both shared a common experience in engineering infrastructures in the landscape, Unwin below ground, Conzelman above ground.

⁶⁰⁵ Ibid.

⁶⁰⁶ Ibid.

⁶⁰⁷ Ibid.

⁶⁰⁸ Ibid. Ernst May would follow the same approach in Frankfurt, as I will demonstrate in Chapter 5. Le Corbusier also discussed his work in this way.

settlement.⁶⁰⁹ For these reasons, Conzelman predicted that instead of ever achieving this “factory ideal”, the future industrialization of housing would combine aspects of the fixed industrial plant with that of the temporary construction plant “in the same operation”, closer to the *laboratory ideal* with which he had developed his own system.⁶¹⁰ Instead of deducing what that would be, Conzelman proposed a mode of investigation that might lead to this new space of production, his own *via latera*. Conzelman explained that it was already possible to “approximate the factory ideal ... on the building site.”⁶¹¹ To do so involved the “construction of a more or less temporary plant”, whose organization attempted to achieve as much of the “factory idea in operation as the (site) conditions [would] permit.”⁶¹² However, the production limits of this approach would be balanced by the fact that the “operation [was] more flexible and fixed charges [were] not so high”.⁶¹³ This approach was particularly suited for the development of a system, giving much “more freedom in the design” and allowing for the “slow process” of the *laboratory method* to occur.⁶¹⁴ While “each experiment” constituted “considerable time and labor” it was “only through the actual construction of housing on a commercial basis” that “real progress (would) be made”.⁶¹⁵

In addition to emphasizing the importance of situating knowledge production within the space of material production, Conzelman emphasized collaboration between

⁶⁰⁹ Ibid., 87. Since Atterbury did not have to consider actual overhead cost and was working with an already defined architectural system, one that he had borrowed from Norman Shaw, he did not consider these issues. On the other hand, Unwin, as part of his work at Hampstead, where other architects were also involved, dealt with a similar kind of indeterminacy.

⁶¹⁰ Ibid., 88. During the postwar period, Soviet industrialized housing delivery actually moved in the same direction, after investing heavily in the factory ideal.

⁶¹¹ Ibid., 84-85.

⁶¹² Ibid., 87.

⁶¹³ Ibid.

⁶¹⁴ Ibid., 88.

⁶¹⁵ Ibid., 87.

disciplines, through a feedback loop between the “construction requirements” of the system and the “plans themselves”, prepared by architects.⁶¹⁶ He also advocated for the use of unit groupings, organized in “terraces or rows”, arguing that they combined ease of construction, addressed client’s desires and would take advantage of site conditions.⁶¹⁷ The scale of a colony itself, more than off-site fabrication, was key, with Conzelman advocating a minimum of 50 units in order to “justify the use of construction methods and equipment and the organization that is usual in large contracting operations”, such as industrial plants or infrastructure.⁶¹⁸ At a large enough scale, one hundred units or more, as was the case in Youngstown, “maximum economy” could be reached by coordinating the “layout of the property”, the “design of the houses”, the arrangement of the temporary construction plant and the routing and scheduling of operations.⁶¹⁹ All of these principles were applied to the work in Youngstown, between 1917 and 1919.

Unwin’s architectural group of units were the basic element used in the planning, production and picture-building of the Youngstown settlement, providing a key link in the collaboration of Conzelman’s team and Herding & Boyd.⁶²⁰ The architect-town planners completed a site survey to identify key features, such as topography, solar orientation,

⁶¹⁶ Ibid., 85.

⁶¹⁷ Ibid.

⁶¹⁸ Ibid. Atterbury’s entire total at Forest Hills, between 1912 and 1918, was around 40. Harms and Small maintained similar numbers as Conzelman, and also preferred a temporary plant. In fact, their forms were designed around this more mobile approach as well.

⁶¹⁹ Ibid.

⁶²⁰ During this period, a new company, Conzelman, Herding and Boyd, was established. This company only existed for the duration of the project, with Herding and Boyd continuing to practice as independent town planners after 1920, working on company towns throughout America. For an example of this later work see Margaret Crawford, *Building the Workingman’s Paradise: The Design of American Company Towns* Haymarket Series (Baltimore: Verso, 1996). Youngstown itself is only briefly mentioned in Slaton, *Reinforced Concrete and the Modernization of American Building, 1900-1930* The project was extensively published in American architectural journals, including *Architectural Review* (1919), *The American Architect* (1918) and *American Architects and Architecture* (1919), but these later articles did not discuss the fabrication and construction process in the same detail as the series of articles in *Concrete*, from 1917-1920. Martin Wagner’s later account of the project in *Wohnungswirtschaft* drew primarily on those articles.

existing roads, as well as infrastructure, particularly the existing railway, which was crucial to Conzelman's temporary plant.⁶²¹ (Fig. 70) Here, unlike at Salindres, the Unit System's spatial and temporal requirements were included in the site surveying process and informed the site design and visual planning of the settlement. Herding and Boyd also followed Unwin's principles in the overall organization of the settlement, starting with a primary center, the "public square", from which a series of secondary centers, each forming a precinct, and tucked away from the more trafficked arteries, emanated. The initial phase of 146 units was located on the northwest corner of the larger parcel, between an existing traffic corridor and the planned town center, while the temporary plant was planned immediately adjacent to the east.⁶²² Following Unwin's principles, the architectural groupings were developed from the logic of the unit up, and not simply form the traffic lines down, being adjusted to the site topography and with an eye towards forming streets and places.⁶²³

Conzelman's earlier panel patents provided the basis for the development of three basic architectural unit types, which in turn served as the basic organization elements of the settlement scheme.⁶²⁴ (Fig. 71, 72) The first panel type, which constituted the party

⁶²¹ "Layout of Housing Scheme for Youngstown Sheet & Tube Co. Shaded Portion Shows Part Under Contract. Faint Dotted Line Above Indicate Layout of Construction Plant". Harvey Whipple, "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.," *Concrete* 12, no. 1 (January 1918): 5.

⁶²² The plant included the manufacturing yard, complete with a mixing plant, a mobile concrete chute and a foundry for fabricating reinforcing.

⁶²³ This scheme drew on Unwin's manual, without explicitly following any one of his settlement projects.

⁶²⁴ A new kind of drawing, the "Detail Layout of Housing Development Now Under Contract with Schedule of Accommodation in Families Per Building", combined information about the settlement and specific unit types with the routing and scheduling of the construction and settlement process. Whipple, "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.," 6. It did for settlement design, what Gilbreth's 1909 drawings of scaffolds, included in *Bricklaying System*, had done for workstation design. Conzelman was also able to provide rough plans, informed by the logics of his patents. The "Typical Floor Plans (A) Single Unit (B) Double Unit and (C) Triple Unit" show the layouts at this interesting moment of development, between concerns for the space of production and

wall of each row-house unit, was initially planned as an eight-inch thick hollow core concrete slab, requiring two steps to be cast. During the process of fabrication and assembly, the resident engineer decided to use a simpler 6 inch thick solid slab for the majority of the party walls between the units, since fire separation could be still be achieved and thermal insulation was less of an issue than at the ends of the groups. These panels were a full story in height and varied in length, cast with a notch to receive the exterior wall panels and with a rib to receive the floor panels, both of which were essentially minor variants of the second panel type. The second panel type, which was used for the floors and exterior walls, was a ribbed panel type, cast flat site down, in two pours. Simple wood formwork was added to cast any openings and to set the ribbing, while windowsills were cast separately and inserted with the formwork during the casting of the exterior panels. Using the basic parameters of the panel system, Herding and Boyd developed three basic plan types: a two-story row-house, with a dining room/kitchen and living room occupying two equally sized cells on the ground floor, separated by a stair, and two bedrooms and one bath on the second level, a two story, interlocking double row-house type, shallower in depth, and with one larger bedroom and bath on the second level, and a two story interlocking triple row-house type, compatible in width to the double row house type, with two two-bedroom units and one one-bedroom unit.

For Conzelman's team, once the basic unit types were set, the variety of the 19 groups of the 146 units provided no significant challenge, in terms of planning, fabrication or assembly. As the "detail layout of part of housing development now under contract with

occupation. Ibid. A series of plans published a year later, show that Herding & Boyd were not as prepared to deal with the potentials of Conzelman's system at the unit scale, as they had been at the settlement scale. "281 Fireproof Dwellings Built of Large Precast Concrete Units," *Concrete* 14, no. 1 (1919): 5-6. While American journals published these later 1919 drawings, Wagner would publish the 1918 drawings.

schedule of accommodation in families per building”⁶²⁵ shows, the design team was able to prepare a scheduling and routing scheme, which translated these groups into tasks, as represented in a modified site plan drawing, as well as a more conventional chart. (Fig. 73) Both projections included the group number, which reflected the sequence of assembly, the total number of units in the group, as well as the unit type, the number of each unit type in a group and the unit type frontage. This new drawing type was a key interface in organizing the various scales and work of the disciplines.

With the organizational system in place, managed by a series of hybrid projection instruments, which linked the site design and visual planning principles defined by Unwin with the laboratory method and Gilbreth’s visualization approach, the fabrication, assembly process and a continuation of standardization, could commence. *Motion pictures* (progress photos) of the temporary plant show all of the basic characteristics of an industrial facility, albeit outdoors.⁶²⁶ (Fig. 74) Two sets of temporary rail were laid around a tear shaped casting platform of packed earth, finished with a thin layer of concrete and open faced simple wood forms. Using the principles and machinery typical of road construction, Conzelman erected temporary towers to hoist chutes which could easily pour concrete into open forms with adequate reinforcing, leaving them to cure. A small locomotive, which was equipped with a hoist and then moved along the track, lifted the cured panels from their horizontal position and placed them vertically for further curing, freeing up space for another panel to be cast. At the peak of production, enough panels for

⁶²⁵ "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.."

⁶²⁶ Although he discussed them at length, Conzelman never published his motion pictures or progress photos. More conventional photographic documentation, of the “casting yard: track for locomotive at left; casting area and tramway at right with tower in background” and “near view of molds for unit slabs” was included in *ibid.*, 7. and would also be republished by Wagner.

the fabrication of 50 dwellings could be in production simultaneously, a third of the initial order.

Once fabricated, five-ton trucks would pick up the panels from the temporary plant and deliver them to their group site as indicated by an assigned filing number.⁶²⁷ (Fig. 75) At the group site, a crane was used to hoist the panel into place on cast in place footings, which served both as a foundation and centering for the panels.⁶²⁸ The fabrication and assembly of Group 1, consisting of two row-house units, was used to further optimize the standard dimensions of the panel joints, resulting in a tolerance appropriate to the size of the panels, the machinery and the skill level of the labor. The joints, which through Conzelman's earlier work had been developed to provide a robust enclosure, were grouted on site.⁶²⁹ Additionally, the thinner ribbed panels, which made up the floors and exterior walls, provided thermal and acoustical performance. After the completion of Group 1, the production of Group 2 and 3 generated a more calibrated sense of the system's basic parameters, including the exact amount of material and time required; these factors would be utilized to manage the remaining seventeen groups, between the fall of 1917 and 1918.

The flexibility of the architectural group throughout the settlement-building process provided that the number of units or their general position might shift to easily accommodate problems encountered during construction, while maintaining the basic ensembles devised by Herding and Boyd through a series of sequential perspectival

⁶²⁷ A series of photos, documenting the "crane taking unit of side wall from casting area", "hoist taking slab from the bus" and "hoist putting slab in place in house" demonstrated the elegance of the system, designed specifically around the motions of assembly, as well as around the limits of on-site fabrication. *Ibid.*, 8-9.

⁶²⁸ These joints provided for greater tolerance in achieving an air and watertight enclosure, as compared to Atterbury's more precisely molded panels, which required a difficult degree of factory precision on the construction site. "Detail of Unit System for Houses", *ibid.*, 9.

⁶²⁹ Conzelman's optimized joints provided a more robust enclosure than Atterbury's highly precise machine finished panels could achieve.

studies.⁶³⁰ As one American critic stated in 1920, the potential “monotony” of the “constant repetition” of only three types nearly 200 times was “obviated in the layout by irregularity of streets, (the) general spacing of house groups and by (the) stepping of house groups”, which responded to and further emphasized the “unequal topography of the community, with steep grades and a welcome necessity for stepping the construction from one grade to another.”⁶³¹ The frequently republished photo of Group I, where the architecture of Conzelman’s system and Unwin’s planning principles is not yet obstructed by the aggregation of cheap building products, is quite distinct from the images of fully completed sections of the project, where much of the beauty of the informally arranged tectonically clear assemblies was obstructed by the application of *ready-made* windows, doors and other building components.⁶³² (Fig. 76) Conzelman had clearly hoped to expand into settlement-building by devising a way to “compete successfully with the ... speculative builder”, but while Herding and Boyd continued to design company towns through the twenties, the Unit System was not directly applied to these projects. When Ernst May and Walter Gropius began to experimentally derive and standardize their own industrialized housing delivery systems, starting in 1926, both showed interest in the Unit System, but more as an organizational system than as a particular mode of fabrication and construction, lacking the mechanization and skill Conzelman’s crew had amortized through his work in infrastructural building work. Crucial to the translation was a common language of

⁶³⁰ The studies were published in Whipple, “281 Fireproof Dwellings Built of Large Precast Concrete Units,” 6. Wagner, who was still designing in a vernacularizing language in 1924, was critical of the overall outcome.

⁶³¹ Ibid., 5. European modernists agreed with this verdict, but found the tectonic relationship of Conzelman’s panels to the standard wooden roof construction and truly ready-made windows, doors and other building products, as having left much to be desired.

⁶³² “146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.,” 5. The same quality is now again visible, since the cheap building products were quickly destroyed while the panels have survived, for nearly a century. For more on the current state, visit ironsoup.com, the web site of the Iron Soup Historical Preservation Society.

industrial organization, through the manuals of scientific management, and of site design and unit design, as well as visual planning, through Unwin's manual of town planning.

The Atterbury, Harms and Small and Unit Systems all focused primarily on the production of building components, on and off the construction site. In Atterbury's case, architectural production, in terms of general aesthetics, tectonics and social organization, followed principles already defined by English architects, particularly Norman Shaw, during the last decades of the 19th century, and was further informed by a partial application of Unwin's town planning techniques, at the scale of the group rather than the entire settlement. In Harms and Small's case, a *directness* in architectural expression was most likely encouraged by Dutch advocates of *Sachlichkeit*, with little innovation in terms of spatial planning, at the unit or settlement scale. In Conzelman's case, a unique balance between his theories and instruments of planning the space of production with those of Unwin, as related to the space of occupation, at the scale of the landscape, was achieved. Nevertheless, all three projects served as important experiments in industrialized settlement-building, informing the work of the late twenties. A new mode of architectural production in relation to the conception, construction and living in houses in *series* or *groups*, informed by the principles of scientific management and town planning would begin to be developed around 1918. This will be the focus of the next chapter.

Chapter 4. Managing Intellectual Work: Peter Behrens' Grouped houses and Le Corbusier's Houses in Series, 1918-1926

In 1926, the soon-to-be director of the “experimental settlements” program, German architect Wilhelm Lübbert, explained that in the near future, types of work related to housing delivery would need to “rationalized”.⁶³³ While, the “rationalization of the production facility” and the “rationalization of the construction site”, had been pioneered in America, with some “experiments already made in Germany”, it was the “rationalization of intellectual work”, the standardization of the instruments and methods of drawings, specifications and other projection instruments, which promised to have the most impact upon housing delivery.⁶³⁴ Instead of the *unproductive* work of “seeking thousands of individual solutions” to essentially the same problem, better instruments of architectural production would allow the modern architect to focus on the “aggregation of individual units” that would form “beautiful house-groups”.⁶³⁵ Additionally, the rationalization of this “unproductive work on paper” would allow architects to again engage, more *creatively*, in “building activity”, as a form of conjecture.⁶³⁶ Only a few months before this text was published, Le Corbusier's *Toward an Architecture* (1923) was translated into German, as “Toward Artistic Building”.⁶³⁷ In that publication, Le Corbusier offered a novel approach to architectural production, one that promised new methods for managing the conception,

⁶³³ Wilhelm Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]* (Berlin: Arbeitsgemeinschaft für Rationalisierung im Bauwesen/Beuth Verlag 1926).

⁶³⁴ Ibid., 14. “Rationalisierung der geistigen Arbeit beim Wohnungsbau”, “Rationalisierung der technischen und geschäftlichen Einrichtungen” and “Rationalisierung des Verbrauches an Baustoffen und Bauteilen. Verbesserung und Verbilligung der Bauweisen und des Betriebes auf der Baustelle.”

⁶³⁵ Ibid., 24.

⁶³⁶ Ibid.

⁶³⁷ Le Corbusier, *Kommende Bau Kunst [Vers une architecture]*, trans. Hans Hildebrandt (Stuttgart: Deutsche Verlags-Anstalt, 1926; repr., 1965).

construction of and dwelling in *houses in series*.⁶³⁸ While he acknowledged that mass production techniques had not yet been applied to housing construction, he argued that this did not prevent architects from beginning to conduct their own research into new means of architectural production, based on already *established* standards of industrialized settlement-building. Le Corbusier believed that those standards were already a kind of vernacular in America, and that from them, new standard practices of architectural production could be experimentally defined and further standardized.

In the previous chapter, I compared three applications of scientific management and town planning to the planning and management of mass production. In this chapter, I will compare two applications of these principles to the management of intellectual work developed by Peter Behrens, between 1917-1920, and by Le Corbusier, between 1922 and 1926. In both cases, the architects consciously chose simpler building systems around which to conduct their “architectural research”. I will contextualize Le Corbusier’s work against an earlier attempt by Peter Behrens, between 1917 and 1920, to develop a system of architectural production, following the principles of scientific management.⁶³⁹ Both referenced Taylor’s laboratory method and the Gilbreths’ visualization approaches and both would draw heavily on the town planning principles of Raymond Unwin, albeit more superficially in Behrens’ case. Behrens would develop his “grouped building method”

⁶³⁸ The English translation of “*maison en serie*” as mass production houses is problematic for a number of reasons. First of all, it emphasizes production, particularly off-site production, instead of the product itself, which was the real problem and topic of the 1922 article. For Le Corbusier, or any architect, the real problem lay in the efficient production of drawings, not buildings, the production of house plans in series. A related problem was that of dwelling in houses in identical series, which Le Corbusier attempted to solve following Unwin’s example.

⁶³⁹ Heinrich de Fries Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* (Berlin: Verlag der Bauwelt, 1918). Behrens’ system, the “grouped building method”, was similarly limited by a lack of laboratory work and by a more superficial understanding of Unwin’s theories and practices, which nevertheless constituted much of the German architect’s “answer to the settlement question”.

within the space of the atelier, before constructing two demonstration projects of his system, near Berlin, in 1919 and 1920, from which he claimed to have found the “answer to the settlement question”. Le Corbusier would expand the space of architectural inquiry from conception, within the atelier, to construction and even to dwelling, through a “series of experiments” near Bordeaux, a more costly endeavor, but one that nevertheless helped him establish and standardize his architectural production principles. Ultimately, both architects would use one of the “experimental settlements”, or *Weißenhofsiedlung*, overseen by Lübbert to demonstrate their standard methods through built artifacts.

Peter Behrens, The Grouped House-Building Method, 1917-1920

As I have already discussed in Chapter 1, Peter Behrens was the first European modernist architect to publish a discussion of scientific management, the laboratory method, and even Gilbreth’s work in construction, in March 1918, as part of his treatise, *Toward Economical Building*.⁶⁴⁰ I will now discuss the approach to architectural production he presented in that manual, the “grouped building method”, which he had not yet deployed or developed through practice at that time. Instead, this approach reflected a decade of experience that had started with his appointment as the artistic director at the AEG.⁶⁴¹ Although he had been exposed to scientific management during that period, he had

⁶⁴⁰ Ibid.

⁶⁴¹ The AEG, called a “practical experiment (in) industrial capitalism” by Max Weber, had begun to apply the Taylor-System, as it was then called, as early as 1898. In 1900, Emil Rathenau boasted to Kaiser Wilhelm II that the “English can learn something from our German factories”, since while the former simply added “one factory onto another”, with each space supporting a specific task, at the AEG, the “whole thing is projected and worked out as unified scheme”, prioritizing “organization” over material quality or the use of mechanized tools alone. While Walther Rathenau had attributed such interest in organization and systematization to the Prussian spirit of military rigor, his father, Emil Rathenau, an English educated mechanical engineer, acknowledged a less patriotic source, America. In 1908, he explained that “(i)ntelligent (German) factory owners had imported more or less automatically functioning machines from America, but could not achieve adequate results”. This shortcoming resulted because they had not yet engaged in the “study of the American methods” of modern management, which ultimately “deepened (his) understanding of modern manufacturing processes and served as a pointer to the direction which (the AEG) was to pursue.” As Taylor

not had an opportunity to practice the approach, participating instead in the AEG's factory-building endeavors in a manner more comparable to Berlage and Hanna's relationship to Harms and Small or that of Herding and Boyd's to Conzelman. Neither Behrens, nor the structural engineers with whom he collaborated, engaged in scientific or systematic management; instead they provided a service within a system designed by Paul Jordan, a trained mechanical engineer, and his team of proto-industrial engineers. They prepared *programs*, in the form of instruction cards, gantt charts and industrial plant plans, around which Behrens raised his factories.⁶⁴² As Behrens himself would later acknowledge, he would rely on the manual of the "old master of city-building, Camillo Sitte", to produce designs for the AEG's industrial plants during this period.⁶⁴³ It was these earlier experiences in *industry-building artistically considered* that would inform his first settlement design, part of the growing AEG company town at Hennigsdorf, near Berlin,

had often emphasized, his own high-speed-steel tools were useless without the standard methods and parameters with which they should be used.

⁶⁴² In his characterization of a few "powerful individualists", experts in their respective fields, being the primary driver of progress, Behrens reflected his own unique position at the AEG. The "enormous productive power" of early industrial capitalism, he claimed, had been created through the combination of "specialization" and a "close collaboration" of different disciplines, in his case the "engineer and the architect". Through this division of labor, Behrens believed the equality between the "physical laws" of the engineer and the "artistic laws" of the architect-artist could be maintained. In fact, it was Paul Jordan, a trained mechanical engineer-turned-industrial engineer, who served as the generalist behind the planning and production of the new AEG factories, while Behrens and other engineers provided expertise but lacked control, or even an understanding of the whole endeavor; in other words, Behrens' role was already somewhat standardized.

⁶⁴³ Within the AEG's industrial plants "the placement of buildings" had first been informed by the "process of manufacture", whose scheduling and routing logics informed the "disposition of trackage" and ultimately "govern(ed) the building location", Behrens' role followed this initial analysis, considering the "stepping back of the buildings", the location of "portals and driveways" where workers and materials entered and exited the various facilities, as well as the formation of exterior production spaces, such as the "loading courts", through the lens of "artistic city-building". For example, the "practical necessity of the recession" of the various factory structures grouped in an industrial plant allowed that "group to acquire ... an effective silhouette". This effect could be further emphasized by the "arrangement of courts", which supported the manufacturing processes, in such a way that the resultant public places, enclosed by the architectural volumes, could define a promenade. Behrens concluded his discussion by explaining that "it is only necessary to have had the opportunity for comparison between layouts directed from a purely practical viewpoint by an understanding mind, and those created by change or time's accretion, granted an equal expenditure in money and equivalent materials, to find an astounding difference in the impression created."

between 1910-11.⁶⁴⁴ This project would directly inform the “grouped building method”, in 1918.

In the initial design for Hennigsdorf, Behrens showed a similar aesthetic sensibility to that of Paul Mebes, using relatively simple architectural volumes, which enclosed courts, but were free from the building line, articulated in the *medievalizing* and vernacularizing language of the period.⁶⁴⁵ However, during the design process, and through the translation of drawing to building, the project changed significantly. First of all, instead of the more common façade material of stucco, Behrens chose to use standard brick.⁶⁴⁶ Using a detail he had developed on an earlier factory project, he constructed the window frames out of brick, choosing a white glazed finish, rather than the natural finish used for the industrial plant.⁶⁴⁷ These windows were at once more formally bold, as they were both resolved to a

⁶⁴⁴ Le Corbusier discussed the proposal in Ch. J. Jeanneret, *Etude Du Mouvement D' Art Decoratif En Allemagne*. (Chaux-de-Fonds 1911). The background surrounding the project is explained briefly in Fritz Neumeyer, "The Workers' Housing of Peter Behrens," in *Industriekultur: Peter Behrens and the Aeg, 1907-1914*, ed. Tilmann Beddensieg in collaboration with Henning Rogge. According to Neumeyer, most of the documentation of the early phase has been lost.

⁶⁴⁵ The original proposal, itself an urban fragment, shows the direct influence of Paul Mebes' large urban ensembles which were being constructed around this time in Berlin and showcased at the 1910 International Urban Design Exhibition. Much like those schemes, the ambition at Hennigsdorf was to provide multi-unit housing comparable in scale and efficiency to the *mietskasarne* types which had, for a few decades, dominated much of Central Europe by generating more complex urban ensembles following Sitte's dictums of enclosedness, silhouette and rhythm. The hierarchy and formality of Behrens' proposal were imposed through the addition of a half-story to the central mass, which was set back from the street by the place, and a reduced articulation of the windows and entries as compared to Mebes' schemes. The original proposal was published in Fritz Hoerber, *Peter Behrens* (Munich 1913). Mebes' scheme was included in Werner Hegemann, *Der Städtebau Nach Den Ergebnissen Der Allgemeinen Städtebau-Ausstellung in Berlin Nebst Einem Anhang: Die Internationale Städtebau-Ausstellung in Dosseldorf* (Berlin: Wasmuths, 1911).

⁶⁴⁶ The palette and the window frame details are very similar to the industrial plant he was completing at that time, the AEG Factory for Transformers, Resistors, and High-Voltage Equipment in Berlin, frequently referred to simply as the High Voltage Factory. Tilmann Beddensieg in collaboration with Henning Rogge, ed. *Industriekultur: Peter Behrens and the Aeg, 1907-1914* (Cambridge: The MIT Press 1984 (1979)), 293-94. Stanford Anderson has shown how influential Camillo Sitte's principles were on this particular project in Stanford Anderson, *Peter Behrens and a New Architecture for the Twentieth Century* (Cambridge: The MIT Press, 2000). Le Corbusier toured the construction site of this factory in June 1910. Allen Brooks, *Le Corbusier's Formative Years* (University of Chicago Press 1999).

⁶⁴⁷ The combination of red brick and white window frames, as well as the reserved vernacular modernist massing around a quadrangle, closely resembled Unwin and Parker's recently completed group of 6 cottages,

finer degree of detail and more directly expressive of the interior organization of the units, than either Mebes' facades, with their applied ornamental stucco, or the more matter-of-fact expression of English domestic architecture. The windows were not merely a reflection of internal tectonic logic but were actually driven by visual planning aspirations, which were attributable to Sitte, yet further developed. Through this technique, Behrens sought to introduce "rhythm", a key principle of "dynamic visual expression" in which the mass was broken down into parts and unified back together by the moving subject, as he explained in a lecture in 1910.⁶⁴⁸ While the "principle of rhythm (was still) of great importance", the moving subject was now more accelerated in "our age ... than that of our fathers".⁶⁴⁹ The modern viewer had "no time for details", the "images of the city that flash past the traveling railway carriage can only have impact through their silhouettes", with "individual buildings no longer (able) to speak for themselves."⁶⁵⁰ Since Sitte had already provided the basic principles to define "city-images" at a larger scale, Behrens decided to provide a new scale of silhouette and rhythm at the building component scale and at the speed of the moving subject.⁶⁵¹ At Hennigsdorf he provided the first examples of these "essential techniques" in the "articulation of large areas", surfaces of brick detailed at their corners to emphasize their thinness, and the use of large white windows and window groups, offering a "lucid contrast between prominent features and widely stretched planes".⁶⁵²

Group 36, 1907, which had also been included in the English section of the International City-building exposition. Reproductions of these drawings are held at the Fogg Museum, Harvard University 3.2002.3293.

⁶⁴⁸ The earlier lecture, "Art and Technology", was delivered on May 26, 1910. Translated and republished in Rogge, *Industriekultur: Peter Behrens and the Aeg, 1907-1914*.

⁶⁴⁹ Ibid.

⁶⁵⁰ Ibid.

⁶⁵¹ Ibid.

⁶⁵² Ibid.

Following the same basic techniques that he had developed in his factory work, Behrens moved from the outside in and relied on an established plan typology of three units grouped around a single stair core, an *established standard* of multi-unit housing in Central Europe by this time. Unlike the manufacturing programs he had received from Paul Jordan, here the basic plan types proved a less flexible organizational artifact to mold. While Behrens carefully indexed many of the interior functions of the individual units on his complex surfaces, the more successful enclosing of the larger public spaces came at the expense of the unit plans themselves. In a subsequent 1914 article titled “The Impact of Considerations of Time and Space on Modern Form Making” Behrens acknowledged this problem.⁶⁵³ Here, he first repeated an earlier discussion of *silhouette* and *rhythm* from 1910, nearly word for word, defining it as a “measure of time, a measure of movement”, and defining modern form as something that was “not fixed”, but “organically alive”, a set of relationships between moving subjects and objects.⁶⁵⁴ In a significant addendum to the 1910 text, made in the 1914 article, he added a warning to other architects that “if urban design and architecture (were) treated according to these principles” one could achieve “great effects”, but that the process of creating these effects could also lead to configurations “contrary to modern buildings themselves, especially in terms of their optimal internal arrangement.”⁶⁵⁵ Overall, his work on housing at Hennigsdorf had lacked

⁶⁵³ Peter Behrens, "Einfluss Von Zeit- Und Raumaussnutzung Auf Moderne Formentwicklung [Influence of Time and Space-Utilization on Modern Formal Development]," *Werkbund Jahrbuch* (1914).

⁶⁵⁴ Ibid. The earlier lecture, “Art and Technology”, was delivered on May 26, 1910. Translated and republished in Rogge, *Industriekultur: Peter Behrens and the Aeg, 1907-1914*, 212-19.

⁶⁵⁵ Behrens, "Einfluss Von Zeit- Und Raumaussnutzung Auf Moderne Formentwicklung [Influence of Time and Space-Utilization on Modern Formal Development]." He called on German architects to abandon “medieval winding streets” and “irregularly angled idyllic places” in favor of “consciously planned ... spacious ... straight streets” following an “axial system”. This appeal is reminiscent of Unwin, who had also sought to separate Sitte’s valuable principles from his school of followers and their willfully *wiggly* schemes, which he found problematic in terms of the efficient and artistic organization of internal spaces.

the systematization of his earlier factory work. However, he hoped that his “grouped building method”, a system of architectural production that could address the scale of the settlement, the unit and the building component simultaneously, a *rationalization of intellectual work*, as was related to the architect and an acceleration of the rhythm of perception, would be a means to address this issue.

Between late 1917 and March 1918, Behrens collaborated with another German architect, Heinrich de Fries (1887-1938), on a design treatise titled *Toward Economical Building: A Contribution to the Settlement Question*.⁶⁵⁶ Confident in his mastery of the settlement and building component scales, Behrens focused primarily on the scale of the unit to be deployed in series and groups. In contrast to Unwin, whose primary scale of study consisted of the building mass and its relationship to the urban ensemble, Behrens included more detailed information, such as the specific location of rooms and the geometry of vertical circulation, entry, apertures and landscaping. He called his approach *Gruppenbauweise*, or the “grouped building method”.⁶⁵⁷ The largest chapter, nearly half of the eighty page pamphlet, focused on what Behrens promised to be “Savings through Planning”, and served as a demonstration of this method, following a format borrowed

⁶⁵⁶ Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]*

⁶⁵⁷ Ibid. Joseph Stubben had included a principle of designing and building he called *Gruppenbau* in his influential manual, *Der Städtebau* (1907), from which Unwin had borrowed and cited many examples. Here, the principle was illustrated through the first phase of Port Sunlight (1905), where the architects, partially in response to the difficult “wiggly” streets laid out by the landscape architect, and partially inspired by the clusters of units published by Shaw, utilized grouped row houses to loosely articulate the oddly shaped blocks; with both the space of the block and the street lacking definition, although somewhat unintentionally, the slab was born as a free-floating object in the landscape. Josef Stübgen, *Der Städtebau*, 2 ed., *Handbuches Der Architektur* (Stuttgart: Alfred Kroner, 1907). While Letchworth had a similar problem, at Hampstead, Unwin was able to give the street, the block and the unit, agency, combining the plasticity of more urban perimeter blocks with the space of rural towns, all designed around a (slow) moving observer rather than the shape of lines on a drawing sheet.

from Unwin's manual.⁶⁵⁸ (Fig. 77) Behrens began his demonstration with a common street frontage of one hundred and five meters. His first diagram, titled *Einzelhausbau*, "single unit house building" method, included seven thirty five-meter deep parcels, each with a forty m² footprint and two hundred m² of garden space.⁶⁵⁹ The next method was the *Doppelhausbau*, or "semi-detached house building", which held the same street frontage but was now occupied by fourteen building footprints, seven groups of two units, with seventy five meter deep parcels, to maintain comparable allotment garden sizes.⁶⁶⁰ Additional studies of more conventional methods were completed with the *Reihenhausbau*, or "row-house building" method, which included twenty-one units with one hundred and six meter deep parcels.⁶⁶¹ The parameters being considered were, first and foremost, the cost of common infrastructure, road and utilities, the ease with which the buildings could be constructed in a series, and the general size of the units. These schemes were then contrasted with the *Gruppenhausbau*, or "grouped house building", scheme of 28 units, actually four groups of seven units each, which Behrens argued were more efficient in terms of cost, leaving the aesthetic implications to be inferred⁶⁶². Whereas his earlier 1910-11 housing consisted of six different unit variants, here Behrens reduced the number of units to three basic unit types, considered in terms of internal organization, then

⁶⁵⁸ Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]* Unwin compared "the advantages and disadvantages of ... two arrangements" of 8 units on a single acre, the first organized as a series on a square plot, each with a "detached house in the center of it", and the second organized as "grouping(s) of buildings", which was more optimal than the first scheme in terms of its efficient land use and superiority, "from the architectural point of view", in the "production of good street pictures" in the public realm and "good vistas" from their interiors to more ample gardens. Raymond Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1909).

⁶⁵⁹ Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]*

⁶⁶⁰ Ibid.

⁶⁶¹ Ibid.

⁶⁶² Ibid.

aggregated into a group, like bricks, creating a common silhouette, and from which they could provide infinite rhythm to an otherwise straight street.⁶⁶³

After comparing his approach to the three more typical settlement-building schemes, Behrens sought to demonstrate the adaptability of the system through a series of variants, which were designed to a more detailed architectural scale and accompanied by perspectival studies.⁶⁶⁴ (Fig. 78) The first of these, Type I, was essentially a row house scheme, where the usual narrowness of the type was addressed by alternating two-level t-shaped units and more rectilinear units; while each of the two unit types had access to the street, their respective “live-in kitchens” had alternating visual and functional connections to their respective subsistence gardens.⁶⁶⁵ Large bay windows connected the units to their gardens, while high hedges maintained the privacy of these outdoor rooms. In the perspective study, the shared entry courts of the four units provided a significant rhythmic void in an otherwise unrelenting building line. Type II was identical to the example used in the first set of diagrams.⁶⁶⁶ Here, the much larger shared entry courts of the seven unit grouping created a much more pronounced rhythm of solid-void at the street scale and the space of the enclosed court was mostly bisected by the hedges of two of the units’ private gardens. Two more types, Type III and Type IV, showed groupings that resulted in an even deeper court, approaching a quadrangle in depth, with the former consisting of seven units and the latter of 6 units, from which the central unit was removed.⁶⁶⁷ In a fifth study, labeled “variant of Type IV”, despite having little in common with that type, Behrens shifted

⁶⁶³ Ibid. Unwin had tried a similar approach in his early work but ultimately moved away from it.

⁶⁶⁴ Ibid., 39-41. The plan, figure 05, is on page 39, and the perspective, figure 06, is on page 41. There is also a section, figure 07, on page 42.

⁶⁶⁵ Ibid., 43-44. The plan, figure 08, is on page 43, and the perspective, figure 09, is on page 44.

⁶⁶⁶ Ibid., 45-46. The perspective, figure 10, is on page 45, and the plan, figure 11, is on page 46.

⁶⁶⁷ Ibid., 47-48. The plan, figure 12, is on page 47, and the perspective, figure 13, is on page 48.

his strategy to generate large, long building masses of four units closer to the street, with pairs of two units set into shallower courts.⁶⁶⁸ In spite of these detailed studies, the system appeared relatively rigid when compared to Unwin's groupings. Furthermore, there was still relatively little concern shown for the standardization of the individual units and few possibilities to respond to site contingencies. In many ways, the scheme suffered from the problems Unwin had attributed to American "trellis planning", where the resolution at the unit scale, repeated infinitely, resulted in problems at the settlement scale.⁶⁶⁹

Instead of resolving the limitations of his system at the macro scale, Behrens would continue, between 1918-19, to focus on the unit-to-group relationship during his work on the first 22 "grouped housing building" method units for Paul Jordan *Strasse* in Hennigsdorf.⁶⁷⁰ (Fig. 79) While most of his previous groupings consisted of two to four unit variants, at Hennigsdorf he attempted to resolve the entire group using a single unit type, paired in a duplex group and enclosing three of the four sides of a raised entry court, with the fourth side open to the street. The basic unit mass would now be constructed of a larger format hollow concrete block exterior load bearing wall, interspersed with lighter partitions, a single standard brick wide. (Fig. 80) In his chapter titled "Savings Through Construction", Behrens had explained that while "standard bricks (were) suitable for *Kleinhausbau*", he was interested in using these larger building blocks in the hopes that,

⁶⁶⁸ Ibid., 49-50. The perspective, figure 14, is on page 49, and the plan, figure 15, in on page 50.

⁶⁶⁹ Sitte had also warned against this approach, explaining that there was "(n)o worse error ... than taking (a) segment of a layout to serve as the rigid schema for a whole section of a town." The "mechanical copying of a set street pattern, it is immaterial which one, is most uninteresting and offensive to our sensibilities". Camillo Sitte, "Improvements in the Modern System," in *The Art of Building Cities: City Building According to Its Artistic Fundamental* (London: Martin Fine Books, 2013 (1889)). Ironically Behrens, a town planner and architect, had limited himself to the group scale that Grosvenor Atterbury had been forced into by the division of labor and hierarchy between landscape-architect-town planner and architect. For more on Atterbury, see Chapter 3.

⁶⁷⁰ Peter Behrens, "Die Gruppenbauweise," *Wasmuths* (1919).

with the help of modern technology, their larger format would lower the cost of transport and assembly.⁶⁷¹ To Behrens, the “typification” of the building component and then the unit plan was prerequisite to “industrialized production” off site, as well as to the “introduction of scientific management to the organization of small housing construction” during the planning and assembly process.⁶⁷² Comparing his approach to that of Taylor, he explained how he too had first started with the “individual task”, be it the laying of brick or the occupation of a single unit, before considering a series of more collective tasks. For Behrens, the Taylor System, as well as typification, were nearly synonymous with a rationalistic problem solving process, which could be conducted in the mind of a “powerful individualist” such as himself. As was found in his earlier texts, the idea of trial and error, the experimental derivation of standards or the evolution of types were not part of the discussion; similarly, the construction of these units were a demonstration of the type, not a continuation of the typification process.

In a 1919 article titled “Die Gruppenbauweise”, Behrens acknowledged a number of criticisms of the recently completed demonstration of his system, particularly the “unnecessary crowding” of the units around the entry court and the resultant “lack of cross ventilation” for four of the six units in the group, but offered little in the way of solutions.⁶⁷³ Instead he focused on what he saw as his methods novel aesthetic qualities and cost savings resulting from his “intention not to plaster” the hollow concrete block exterior

⁶⁷¹ Peter Behrens, *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage. [toward Economical Building: A Contribution to the Settlement Question]*

⁶⁷² Ibid.

⁶⁷³ Behrens, "Die Gruppenbauweise." Here Behrens would show a similar interest to that of Muthesius in the work of NADI and its subcommittee of building construction, explaining that “(b)etter results, to cheapen the construction may be hoped for by the norming of components that was being sought by NADI, also by simplifying the operation in the sense of the Taylor system, and finally by their own cooperation the settlers themselves.” This was the first mention of the Taylor System and scientific management in this influential journal.

walls, allowing the particular “format and grey color of the material” to be visible, and to which “the colorful wooden details” of the window and door frames “would form a welcome contrast.” In his next, and last, application of these principles to 36 units at Lichtenburg (1919-20), a suburb of Berlin, instead of attempting to resolve these problems, Behrens simply chose another one of his existing type variants, which did have a more ample court and better cross ventilation.⁶⁷⁴ (Fig. 81) Behrens also applied a more conventional plaster coat to this project, perhaps in response to a combination of the aesthetics and poor thermal performance of the exposed concrete block, with a similar environmental enclosure applied in 1920-21 to a second set of units on Paul Jordan Strasse in Hennigsdorf.

While his contribution to the *Weissenhofsiedlung* shows some traces of these earlier principles, Behrens mostly abandoned this approach in his later work and would not write about Taylor or scientific management in any detail.⁶⁷⁵ As Stanford Anderson pointed out, Behrens never fully grasped the productive tension between *norm* and *form* that Hermann Muthesius had theorized in 1914.⁶⁷⁶ In his earlier factory work, the systems programming provided by Paul Jordan and his teams provided the norms he needed to freely explore

⁶⁷⁴ In the 1918 manual, Behrens indicated that he was planning to apply his grouped building method throughout Hennigsdorf, as indicated by a plan and perspective in the concluding chapter. Even the initial plan for Lichtenberg shows only a partial application of this method. The plan was published in Paul Joseph Cremers, *Peter Behrens* (Essen: Baedeker, 1928).

⁶⁷⁵ His work in Stuttgart would also be reviewed by the RFG, in "Bericht Über Die Siedlung in Stuttgart Am Weissenhof," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Sonderheft Nr. 6, no. Gruppe IV, Nr. 3 (April 1929). For more on Behrens' contribution to that project, see Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*.

⁶⁷⁶ *Peter Behrens and a New Architecture for the Twentieth Century*, 218. Anderson argued the following: “Now if Behrens occasionally found a viable middle ground between norm and form, convention and expression, type and individual prior to 1914, and if an artist like Le Corbusier was capable of greatly extending the position after 1914, why was Behrens so ineffectual in the Werkbund debate of 1914? Apparently he had never, for all his devotion, fully grasped the possibility of creatively developing norms (as Le Corbusier later did). For Behrens, norms and conventions had a strongly retrospective character, carrying with them the powerful associations of their prior use.”

form, but when he attempted to act as the designer of *norms*, as well as *forms*, he was significantly less successful. As I will show in the next section, his former employee, Le Corbusier, proved more prepared to engage and apply the laboratory method to architectural production.

Le Corbusier, Conceiving, Constructing and Dwelling in Houses in Series 1922-1926

In 1950, Le Corbusier characterized his “method” of the early twenties, as “laboratory work” in “organization”, work that he saw as crucial to the development of his approach to architectural production.⁶⁷⁷ The first step in this approach included “normalization”, the ability to “recognize the type and distinguish it from its variants”.⁶⁷⁸ This step was to be followed by the process of “standardization”, a “word of Anglo-Saxon origin”, a “product of the industrial revolution” and closely associated with “American industrialism”, which had only “more recently entered the French language”.⁶⁷⁹ Although standardization was “intimately linked to mass production” it was distinct from it, allowing for the kind of scalability of organization that “enabled the United States to manufacture and sell baths as easily as saucepans”. Whereas the act of normalization “identified the type

⁶⁷⁷ Le Corbusier, *The Marseilles Block* [L'unité d'habitation de Marseille], trans. Geoffrey Sainsbury (London: The Harvill Press, 1953 (1950)), 29. Here, he sought to use his earlier work to frame a new laboratory, the Unite d'habitation in Marseilles. This project served as more of a demonstration than a laboratory, as compared to the earlier work in Bordeaux. While Le Corbusier presented the building systems used at the Unite as already being a kind of vernacular, assuming that the factories that had been prefabricating the single family houses immediately after World War II, in France and in England, could be adapted to finally realize his “immobile villas” and “vertical garden cities”, this was not the case. Instead, the French building industry developed along the lines of the panelized systems used by Atterbury and Conzelman.

⁶⁷⁸ Ibid. Normalization was actually a German term, a translation of the term standardization. In German usage, it was actually more similar to “measure” or “dimension”, the third step in his process. Here he equates it with type, whereas in Germany, during the twenties, type was used to denote a category or a set of relationships, but not specific norms or dimensions. Le Corbusier’s notion of normalization, the recognition of a type, is actually the equivalent of Muthesius’ notion of *typung*, also essentially a form of identification, not invention, and closer to Le Corbusier’s earlier idea of *establishing* a type.

⁶⁷⁹ Ibid., 30. Here, he specifically made reference to his 1920 article, “Eyes That Do Not See”, quoting his own statement that the “discovery of a standard leads to perfection”. Here the term “discovery”, as opposed to “recognition”, suggests a more active engagement, closer to that of the experimental derivation of a tentative standard discussed in scientific management literature. In Le Corbusier’s usage here, standardization included both steps of the laboratory method, experimentation and standardization.

and established its validity”, the “laying down of a standard”, was a more drawn out and active process. Even when standardized, a method or instrument was still tentative; it would “(remain) fixed... for a long or a short time ... until there (was) good reason to change it.”⁶⁸⁰ The standard suggested specific relationships, as opposed to “measure”, the third term, which denoted specific dimensions.⁶⁸¹ Whereas Le Corbusier acknowledged the American roots of the standard, while suppressing the German roots of his understanding of *Typ und Norm*, measure was said to be the “pride of the French people”. Dimensions were set by specific industries.⁶⁸² The last term and step discussed was “proportion”, linked with the notion of “harmony” and more specifically the great “Mediterranean civilization(s)”, it constituted the corrective measures applied to a specific ensemble by an author with aesthetic training.⁶⁸³

As Allan Brooks has accurately pointed out, Le Corbusier was a “person who covered his own tracks”, suggesting that the architect’s accounts of his own work were often carefully designed to emphasize or omit certain sources.⁶⁸⁴ However, in the 1950 discussion of “method”, a lack of reference to Muthesius or Taylor in the discussion of types

⁶⁸⁰ Ibid.

⁶⁸¹ Ibid., 30-31. His definition of measure was in fact the German definition of norm, a fixed standard, usually a dimension or some other numerical parameter. For the official definition of type and norm during the twenties in Germany, see Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]*. I will discuss this in more detail in Chapter 5.

⁶⁸² Corbusier, *The Marseilles Block*.

⁶⁸³ Ibid., 31. A number of scholars during the postwar period argued that this last step was in fact Le Corbusier’s primary mode of architectural production, informed by avant-garde art practice. The most explicit example of this argument is included in Colin Rowe, “The Mathematics of the Ideal Villa,” in *The Mathematics of the Ideal Villa and Other Essays* (Cambridge: The MIT Press, 1987 (1947)). Here, Rowe implies that Le Corbusier began his projects with the principles of Academic Composition, and suggests that Le Corbusier hid this fact. However, Le Corbusier always acknowledged the application of *traces regulatures* as a corrective measure. In his text, Rowe is actually arguing with Siegfried Giedion, who attempted to remove all references to Academic Composition, as generative or corrective measure, from Le Corbusier’s work, starting in Siegfried Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton*. (Berlin: Klinkhardt and Biermann Verlag, 1928).

⁶⁸⁴ Brooks, *Le Corbusier’s Formative Years*, 488. Brooks adds that what Le Corbusier “himself claimed, or implied, was the consequence of his own original thinking, or which he ascribed to non-German sources, was actually the direct result of what he learned in Germany.” This included English town planning, ‘Mediterranean’ proportions, and German city-building. 252.

and standards is less a reflection of conscious omission than a deep integration of those ideas into Le Corbusier's unique approach to architectural production, just as his education in craft, his interpretation of Academic composition and his incorporation of avant-garde art practice were intrinsic to his work.⁶⁸⁵ As he explained in 1929, while his *hands* "were soiled by the scourings of past centuries" and decades, he preferred "washing them to having them cut off."⁶⁸⁶ I will examine his *handiwork* for *traces* of the laboratory method, Muthesius' theories of typological evolution and Unwin's methods of site design and visual planning, particularly through a "series of experiments" conducted in Bordeaux, between 1924 and 1926.⁶⁸⁷ That sequence included the Maison Du Tonkin, a single house, Lège, a group of six *houses in (two) series*, and concluded with the "laboratory of standardization, industrialization and Taylorization" at Pessac, with forty-nine *serialized houses* in all. I will argue that Le Corbusier designed this *laboratory* with the conscious goal of *establishing*, or experimentally deriving, and *standardizing* a mode of architectural production for conceiving, constructing and settling houses in series, a task at which he was successful.

The fact that Le Corbusier's methods were developed in this way lends credence to his claim of having Taylorized his work, despite the fact that, as Bryan Taylor has

⁶⁸⁵ While Rowe, Emil Kaufmann, Reyner Banham, and other scholars, emphasized the Academicism of Le Corbusier's work, more recent scholarship, like that of Allan Brooks and Francesco Passanti has balanced this account, pointing to the continued importance of the vernacular. Francesco Passanti, "The Vernacular, Modernism, and Le Corbusier," *Journal of the Society of Architectural Historians* 56, no. 4 (December 1997). Stanford Anderson has argued that Le Corbusier, as well as other modernists, particularly Adolf Loos, did not simply apply or abandon earlier disciplinary conventions, but they did critically assess them, transforming some and discarding others. This in turn made room for new conventions to be incorporated. Stanford Anderson, "Critical Conventionalism in Architecture," *Assemblage*, no. 1 (October, 1986).

⁶⁸⁶ From the introduction to the P. Jeanneret Le Corbusier, *Oeuvre Complete* (Paris: W. Boesiger et O. Stonorov, 1929). The English translation, by P. Morton Shand, is from the 1936 edition, page 13.

⁶⁸⁷ In the first edition of the *Oeuvre Complete*, Le Corbusier referred to all three of the projects at Bordeaux as a series of experiments, laying them out in the sequence with which they served the process of standardization. *Ibid.*, 68-69, 78-88. They sat between the Villas Roche-Jeanerette (1922-23), where an early version of the architectural promenade was attempted, and the Villa Meyer (1925), an early example of a more mature free plan. By the second edition, in 1936, the Maison du Tonkin and Lège were removed, and with them, the *traces* of the complete experiment.

accurately pointed out, the project was not economically efficient or particularly mechanized.⁶⁸⁸ While Grosvenor Atterbury, George Harms and Henry Small and John Conzelman had, to varying degrees of ambition and success, applied the laboratory method and Gilbreth's visualization theory to the development of their systems of fabrication and construction, Le Corbusier was the first to apply similar principles to architectural production, namely that of a drawing set. That drawing set functioned like an instruction card or a route model, serving as an instrument of feedback, as well as control, during the construction and settlement process, expanding conception out of the mental space of the architect and disciplinary space of the atelier.⁶⁸⁹ Le Corbusier, like Behrens, did not seek to develop a new fabrication and construction system, as Atterbury, Harms and Small and Conzelman had, but rather to develop a system of architectural production that was more compatible with industrialized housing delivery in general. While he was not entirely successful in achieving this goal, his work would directly inform the more thorough laboratory work, in architectural and building production, of his German colleagues, particularly that of Ernst May, starting in 1926.⁶⁹⁰

I will start this analysis by first examining the article that most directly outlined his approach in Bordeaux, "Maisons en série", the summation of a theoretical argument regarding the nature of architectural production; an argument in line with the "modern spirit" that scientific management had described, that had first been set out in *Après le*

⁶⁸⁸ Bryan Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing* (1972).

⁶⁸⁹ This is where his work is distinctive from Peter Behrens' grouped building method, a mode of architectural production that was derived primarily through the translation of ideas to drawings, with the two built iterations serving to demonstrate more than to further investigate this approach as a method of conjecture and management of the space of production and the space of perception.

⁶⁹⁰ See Chapter 3. May drew most heavily on two sources – John Conzelman and Le Corbusier, both of whom he acknowledged in his journal, *Das Neue Frankfurt*.

Cubisme (1918), and further refined in “Eyes That Do Not See: Automobiles” (1920). I will also provide a brief account of the projects, included in the 1922 article, developed between 1914 and 1920, following Unwin’s organizational schemes, included in his 1909 manual. I will then provide a brief background of the staging of the laboratories at Bordeaux, before examining the particular architectural production methods established and standardized there, between 1924 and 1926.

“Houses in Series”, 1922

Le Corbusier’s interest in developing a system of architectural production for houses in series can be traced back to 1910, when Charles L’Eplattenier, his mentor, charged him with a secret assignment, the development of an urban design manual he would call “Le Construction de Villes”.⁶⁹¹ Although he abandoned, or as Brooks has suggested⁶⁹², postponed, the publication of this work in 1915, this unfinished assignment had resulted in a familiarity with Camillo Sitte’s *artistic city-building* and Unwin’s *town planning*, and also informed his interest in Auguste Choisy’s *dissymmetrical* characterization of Hellenic temple complexes.⁶⁹³ Between 1910 and 1922, Le Corbusier’s own emerging methodology moved away from the models (medieval towns or temple precincts) and modes of

⁶⁹¹ For a thorough discussion of this manuscript, see the introduction to Charles-Edouard Jeanneret, *Le Construction Des Villes* (La Chaux-de-Fonds 1987 (1910)). Here, the editor, Marc E. Albert Emery, credits Allen Brooks for first discussing this work. He also explains that Le Corbusier would acknowledge its existence, a “silly little book on urbanism” in an interview in 1966. Brooks has discussed it in detail in Brooks, *Le Corbusier’s Formative Years*. While Emery and Brooks emphasize the importance of Sitte’s 1889 manual, which was certainly the initial source for this work, I have noticed an interesting shift from a focus on Sitte, before Le Corbusier’s Berlin period, starting in June 1910, to that of material from Unwin’s *Town Planning in Practice*, afterwards. It was also during this period that Le Corbusier met Hermann Muthesius, was exposed to the Taylor System, through tours of the AEG’s facilities and his work for Behrens, and witnessed, even possibly collaborated on, the settlement design for Hennigsdorf, all of which are discussed in Brooks.

⁶⁹² Brooks argues that *Urbanisme* (1925) follows almost exactly the same structure as the earlier manuscript, albeit with a different agenda. *Le Corbusier’s Formative Years*.

⁶⁹³ Auguste Choisy, *Histoire De L’architecture* (Paris: Serg, 1976 (1889)). Le Corbusier discovered Choisy well after Sitte and Unwin, both of whom admired the picturesque qualities of Greek Temple precincts. Choisy’s studies of temple precincts did come closer to the particular mix of large scale and detailed intricacy of Le Corbusier’s own work.

expression associated with these methods (medievalizing, vernacularizing or classicizing) while mastering and transforming these methods. After 1922, he began to apply these methods, which had been developed at the scale of the settlement (or industrial plant), to the scale of the house, or house grouping, a transformation that was completed by 1926.⁶⁹⁴ Between 1922 and 1926, he attempted to design at the scale of the settlement, with the intricacy of an industrial product and at the resolution of an architectural work, to *conceive, construct and settle houses in series*. His interests in the cheap industrial vernacular of American ‘concrete towns’, some of which began appearing in France during the summer of 1914, and in the principles of American industrial management, which he had seen, both through his employment with Behrens in Berlin, in 1910, and his collaboration with American industrial engineers on a series of slaughterhouses, in 1917, were both informed by an earlier interest in the problems of architectural production.⁶⁹⁵ The modern settlement was discussed briefly as part of his first discussion of *Taylorisme*, in 1918, and in

⁶⁹⁴ A number of authors have suggested that Sitte, Unwin and Choisy’s visual planning, at the urban ensemble scale directly informed Le Corbusier’s innovative architecture, after 1922 and particularly after 1926, including Robert Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier* (Cambridge: MIT Press, 1982), Brooks, *Le Corbusier’s Formative Years*, and most explicitly, Richard Etlin, *Le Corbusier and Frank Lloyd Wright: The Romantic Legacy* (1994). Etlin has argued that “Le Corbusier’s mind then, the lessons of sequential spaces and balanced picturesque compositions taught by Sitte and Choisy and confirmed by the experience of a trip to the East came together to establish the primacy of the architectural promenade while offering guidelines for its realization,” starting at the Villas Roche-Jeanerette (1923-24). Etlin omits Unwin; I will show his importance, between Sitte and Choisy. This omission is already acknowledged in John MacArthur, *The Picturesque: Architecture, Disgust and Other Irregularities* (2007). Here, MacArthur expands the importance of 19th century visual planning, or the picturesque, much more broadly.

⁶⁹⁵ Allan Brooks has shown that it was Peter Behrens who first introduced Le Corbusier to the expressive potential of American *ersatz*, or “replacement”, building systems in 1910. He has also confirmed Le Corbusier’s familiarity with at least one of the American manuals of these techniques from this period, Maurice M. Sloan, *The Concrete House and Its Construction* (Philadelphia: The Association of American Portland Cement Manufacturers, 1912). I will discuss this in more detail later in the chapter. An interest in this new international industrial vernacular motivated Le Corbusier to work for the S.A.B.A. (*Societe d’Applications du Beton Arme*). Le Corbusier would have a similar relationship to a group of American industrial engineers while working on a series of slaughterhouses, that Behrens had had with Paul Jordan at the AEG, in 1917-18, around the time his personal correspondence began to include references to Taylorisme. Brooks, *Le Corbusier’s Formative Years*, 485.

his more refined discussion of the laboratory method in 1920.⁶⁹⁶ In that article Le Corbusier also showed interest in an even more important form of standards, namely legislation regarding affordable housing, proposed by Louis Loucheur (1872-1931), the Minister of Industrial Reconstruction, also known as the Loucheur Act. His 1922 discussion of “houses in series” would begin with reference to this proposal.⁶⁹⁷

Le Corbusier began his 1922 article with a discussion of the potential implications of a proposal, submitted to the French parliament by Mr. Loucheur and Mr. Bonnevey, for a housing program to support the delivery of 500,000 units, in order to alleviate the postwar housing shortage.⁶⁹⁸ The scale of that proposal suggested that the “modern spirit”, which had already informed the “engineer’s aesthetic” and whose underlying principles were

⁶⁹⁶ “Les banlieues des villes dans un chaos au travers duquel il faut savoir discerner, nous montrent des usines où la pureté des principes qui ont présidé à leur construction réalise une harmonie certaine qui nous paraît s’approcher de la beauté.” Amédée Ozenfant and Charles-Edouard Jeanneret, *Après Le Cubisme* [After Cubism], Commentaries Sur L’art Et La Vie Modern (Paris November 15, 1918), 29. The same sentiment is reinforced, through a photograph, in Le Corbusier, “Vers La Ville Radieuse - Vivre! (Habiter),” *Plans 4* (April 1931). (Fig. 42) Housing is also discussed in “Des Yeux Qui Ne Violent Pas... Iii: Les Autos,” *L’Esprit Nouveau* 10(1920). Portions of this discussion are repeated, word for word, in “Houses in Series”.

⁶⁹⁷ Louis Loucheur had a background in armament production, before becoming the Minister of Munitions in September 1917. Between November 26, 1918 and January 20, 1920, he held the post of Minister of Industrial Reconstruction. He was Minister of Commerce, Industry, Posts, and Telegraphs in 1924, and the Minister of Finance, between 1925 and 1926. It was in this role that Loucheur attended the partial opening of the Quartiers Modernes Frugès in May 1926. He was again Minister of Commerce and Industry between 1928 and 1930, when the Loucheur act finally passed. For more on Loucheur see Stephen Carls, *Louis Loucheur and the Shaping of Modern France 1916-1931* (Baton Rouge: Louisiana State University Press, 1993). Le Corbusier’s work during the twenties essentially parallels that of the development of this Act. In fact, he would choose to begin his work at Bordeaux through the establishment of a standard unit modeled on the basic parameters of an older affordable housing program, still in force in France at this time, the Ribot Law, from 1908. That law was influenced by the garden city movement, with a draft proposed and discussed at the 1907 Town Planning in Theory and Practice Conference in London. *Town Planning in Theory and Practice*, Town-Planning Conference (London: The Garden City Association, October 25, 1907). In the proceedings: “The Scandinavian countries had Town-planning, so had Switzerland, so had Holland and Belgium, Italy and Austria, and, indeed, all civilized countries except England, the United States, and France. Indeed, France had Town-planning de facto, though not by virtue of such laws as existed in other countries. Paris had a splendid arrangement of wide streets. But the improvement of French towns, owing to the want of such laws, had been found to be so extremely costly that there was now a group of Members of Parliament who were pressing for the passing of a law which would give them the same powers of planning new parts of their towns which German and other towns possessed.” Page 42-43.

⁶⁹⁸ This passage was essentially repeated from the 1920 article. This article would also evolve over the course of the twenties. For example, a project for a Maison en Serie by Auguste Perret, Le Corbusier’s former employer, would be removed, and new projects, particularly the work at Bordeaux, would be added.

explained by Taylor and others, needed to expand from a few of France's "larger-scale industries and specialized machine shops", to institutions more closely related to housing delivery.⁶⁹⁹ *Taylorisme* had not yet *infused* construction or led to the *serialization* of building components and most of the building industry lacked this *spirit*. There were "no factories" of building products, "no specialized technicians" to manage the assembly of components on site, and in fact, "specialization", the essence of systematic management and the prerequisite for the synthesis of scientific management, had "barely touched the building trades".⁷⁰⁰ Certain products, including "cement and lime, insulation, plumbing, hardware, waterproof coatings, etc." had been partially standardized according to the "spiritual attitude" of the epoch, but this process had been done primarily for ease of fabrication, and with less consideration for spatial planning, either in terms of construction or occupation.⁷⁰¹ The organization of the construction site, he argued, had changed little since the Middle Ages, when raw natural materials, brought by horses, arrived on site, building components were dimensioned on site and one had time to construct a building over a number of years. In order to achieve the industrial efficiency promised by exceptional systems, like those where "houses are poured from above with liquid concrete in one day", the planning of the construction site and the house itself would have to change.⁷⁰² If the "Laws of Economy" were to be addressed, the same precision which had

⁶⁹⁹ Le Corbusier, "Maisons En Série," *L'Esprit Nouveau* 13(1922): 1525. Cohen, 255.

⁷⁰⁰ Ibid.

⁷⁰¹ Ibid., 1526. Cohen, 255. In the original version, Perret's *maison en serie* was also included on this page.

⁷⁰² Ibid., 1531. Cohen 259. Here Le Corbusier asks "Will construction sites soon be factories?", not whether factories will be mass producing houses. Muthesius discussed single pour houses in 1918, making specific reference to Edison. Hermann Muthesius, "Der Typenbau (Type Building)," in *Kleinhaus Und Kleinsiedlung* (Munich: F. Bruckmann A.-G., 1918). Le Corbusier makes no specific reference to Edison. It is likely that he knew of Harms and Smalls work. He even prepared a scheme for housing for the St. Gobain company, included on page 1528-29, to be constructed out of "liquid concrete", a commission that Harms and Small actually received. Henry J Harms, "Building Concrete Industrial Houses by Harms System in France," in

been applied to the “replacement of natural materials” containing “unknown heterogeneous” properties, by “artificial materials” that had been standardized through “laboratory tested and fabricated with fixed properties”, yet “infinitely variable”, such as the “standard steel section and, more recently, concrete”, needed to be applied to the planning processes of construction and dwelling.⁷⁰³

While Le Corbusier advocated that architects become involved in furthering the “rational study of (building) components”, and “more importantly, the rational study of the construction process itself”, areas already pioneered by industrial and construction engineers, he did not specifically advocate that architects should focus on innovation in fabrication.⁷⁰⁴ Rather the *new spirit of Taylorisme*, with its emphasis on *analysis and experimentation*, in order to establish standards, and standardization, through competition, in order to further *perfect* form, needed to be applied to areas of existing disciplinary expertise.⁷⁰⁵ In housing, this “spiritual attitude of the series” was “resented by architects and residents” alike.⁷⁰⁶ Speaking autobiographically, Le Corbusier stated, “we have rightly

Concrete Houses: How They Were Built, ed. Harvey Whipple (Detroit: Concrete-Cement Age Publishing Co., 1920 (1918)). Le Corbusier was interested in how architectural production might change as a result of this newly established standard, and how architects might participate in its further standardization.

⁷⁰³ Corbusier, “Maisons En Série,” 1530. Cohen 258. The French text reads “épreuves par des essais de laboratoire et produits avec des éléments fixes”. The translation in Cohen is “laboratory tested and produced with standardized elements”. I have chosen to translate it as “fixed properties”, since Le Corbusier uses the term “standardization” in a specific way, following the principles of scientific management. Here, the influence of Taylor and Le Chatelier, both trained metallurgists, is clearly detectible. Taylor and White had become famous for their laboratory work on steel, and Taylor and Thompson for their laboratory work on concrete mixes.

⁷⁰⁴ Ibid., 1526. Cohen 255. “C’est que l’état d’esprit n’ existant pas, on ne s’est pas livré à l’étude rationnelle des objets et plus encore à l’étude rationnelle de la construction elle-même...” Instead of translating the term “objets” simply as “objects”, I have translated it here as components, as in building components. Le Corbusier is more cautious about arguing for the rationalization of architectural objects and especially settlements, although less explicitly than Muthesius had been in 1918/1920.

⁷⁰⁵ Le Corbusier continued to use the same terminology established through his earlier 1918 and 1920 texts.

⁷⁰⁶ Corbusier, “Maisons En Série,” 1526. Cohen 255 Harms and Small had made essentially the same argument, two years earlier. Here, for example, the translation “mass production state of mind” would make little sense. It was the repetitive nature of industrial products that was the problem, not the way they were

run out of breath” calling for “r-e-g-i-o-n-a-l-i-s-m-e!”⁷⁰⁷ Although it would take “twenty years” or more for the industrialization of housing delivery, a fairly astute prediction, Le Corbusier believed that French architects could begin working on transforming their own mental work immediately.⁷⁰⁸ By embracing the “attitude, following the (modern) spirit, of constructing housing in series”, an approach that already existed, at least according to American journals, architects could promote both the “dwelling in houses in series” and “conceiving [of] houses in series”.⁷⁰⁹ As a result, the house, designed to be experienced synchronically, could simultaneously participate in a collective diachronic development of conceiving *serial houses*, which reflected established tentative standards, as well as a departure point and instrument for further, open-ended, standardization.⁷¹⁰ The tentative standards introduced in 1922 were not meant to be ideal solutions to the *difficulties*,

produced. The means of material production was not the problem, it was the experience of the products, in series, and how to conceive these serial products, as an architect.

⁷⁰⁷ Ibid. He gives a specific example: “This example, which deserves to be cited: to put pressure on the Company of Northern Railways to oblige to build on the Paris-Dieppe line thirty different styles stations, because thirty stations that express shine, each have a hill like that are well apple has it and who are his character, his soul etc. ... Fatale panpipes!” Here the discussion is about the rationalization of architectural production, the production of designs in series, with the consideration that they will also be experienced serially, in this case literally from the window of a moving train. Regionalist language was not a solution, but a design approach, based on the evolutionary and adaptive logics of vernacular architecture and industrial production, which could serve to inform a new form of architectural production, one that would marry repetition with difference.

⁷⁰⁸ Ibid., 531. Cohen 259. Le Corbusier’s forecast is impressive in many ways. The first large scale industrialized housing delivery system in France, the Camus System, developed by Raymond Camus, would appear by that time. By that time, Le Corbusier’s own chosen building system, the mélange of reinforced concrete frame and cement or ceramic block infill would also become a vernacular in much of Europe, the Middle East, North Africa and South America, although it would never become as common as he believed it to already be in 1922 in America. Today, this system is even more widespread, while the Camus System and others like it, are extinct.

⁷⁰⁹ Ibid., 1534. He moved this phrase to the beginning of the article, starting in the first edition of *Toward an Architecture*. The original text reads as follows: “Il faut créer l’état d’esprit de la série, L’état d’esprit de construire des maisons en série, L’état d’esprit d’habiter des maisons en série, L’état d’esprit de concevoir des maisons en série.” The “spirit” is short for the “modern” or “new spirit”, the spirit that was explained, not invented, in the publications of scientific management.

⁷¹⁰ The serial houses included in the 1922 article, and its later variants, all attempted to show how an established standard could be varied, to respond to local conditions, as in the case of the Maison Citrohan, which would be shown with and without *pilotis*, depending on the site and the client, or the Houses for Artists and Houses for Artisans, added in later versions, which were designed so as to be grouped in such a way that while each face was different, it formed a collective space between the units.

preconditions or contingencies, such as newly established standard building systems, social requirements or site conditions, but rather they were the instruments with which Le Corbusier had hoped to engage these contingencies, through his own laboratory work. Serial houses, like the Villas Roche-Jeanerette (1922-23), would in turn lead to the "study of standardization at a housing colony", in Bordeaux, which not only reflected the establishment of standards, but the active process of standardization, through a process of conception, construction and dwelling, as Le Corbusier would himself explain in a spread in *Oeuvre Complete* in 1929.⁷¹¹ (Fig. 82)

For Le Corbusier, a new means of architectural production would not only assist in the conception, construction of and dwelling in houses in series but this process would be a productive noumenal and phenomenal activity in its own right, just as standardization for Taylor, typification for Muthesius and individualization for Unwin were means, as well as ends.⁷¹² In 1929, Le Corbusier explained that when one is "speaking of houses in series, one must speak of settlements."⁷¹³ While standardized "building components" provided the

⁷¹¹ Le Corbusier, *Oeuvre Complete*, 66-67. The label and caption of the Pessac diagram would change in the subsequent editions from the "study of standardization at a housing colony", or "Studien zur standardisierung von wohkolonien" in the 1930 German translation, to *maison standardisée*, or "standardized villa". The diagrams would remain the same. Ibid. *Oeuvre Complete 1910-1929* (Paris: W. Boesiger et O. Stonorov, 1936), 68-69. The diagram included here was first published in Le Corbusier, "Standardization, Industrialization, Taylorisation," *Bulletin du Redressement Francais* (May 1, 1928). Part of the diagram was included in an even earlier article, "Appeal Aux Industriels," *L'Almanach d'Architecture Moderne* (1925), an article that would be reproduced in its entirety in *Oeuvre Complete*. That article appealed to French industries to establish and even dimensionally fix window assemblies, demonstrating that they would not lead to monotony, but could in fact generate variety through appropriation by individual designers and users.

⁷¹² Hermann Muthesius came closest to the same conclusions when discussing the work of Norman Shaw, who had supposedly consciously chosen to *evolve* the Kleinhaus type through his work at Bedford Park. Hermann Muthesius, *The English House, Volume I: Development*, trans. Janet Seligman (London: Frances Lincoln Ltd., 2007 [1904]). As Brooks has shown, Le Corbusier had not only attended Muthesius' lectures and read his publications, but the two would tour *Siedlungen* together during the summer of 1910. Brooks, *Le Corbusier's Formative Years*.

⁷¹³ "Quand on parle de maisons en série, il faut parler de lotissement." Le Corbusier, *Oeuvre Complete*, 24. A year earlier, Siegfried Giedion would claim that "individual houses do not satisfactorily demonstrate" the new form of aesthetic quality that distinguished modern architecture from pre-modern architecture, which he would later call "space-time", only *Siedlungen*, or "settlements", with the "relation of several houses to each

“unity”, and therefore “guarantee beauty”, it was the “settlement” design that provided the “diversity necessary for a (successful) architectural ensemble”, that alternated between the “overall order” and “rhythm” of interchanging parts.⁷¹⁴ In the 1922 text, Le Corbusier equated a large scale industrial building, the “salon de aviation”, to the products of *artistic city-building*, including the *Procuratie* in Venice, as well as the *Rue de Rivoli*, *Place de Vosges*, *la Carriere* and *Versailles*, all architectural groupings arranged around an open quadrangle.⁷¹⁵ He explained that all of these examples followed a basic principle of “uniformity in the details”, “tumult in the ensemble”, and “unity in the overall silhouette”.⁷¹⁶ In addition to these historical examples, Le Corbusier augmented his design theory with examples of his own work. While I will examine the projects that most directly influenced the work in Bordeaux, his *Lotissements Domino*, or “Domino Settlements”, I will first analyze Le Corbusier’s initial attempt at a *Cité Jardin*, or “garden city”, proposal, the *Cité Jardins aux Cretets*.

other,” would. Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton*. After 1929, when architectural works like the Villa Savoye and Ludwig Mies van der Rohe’s German Pavilion in Barcelona accomplished the same qualities, critics like Giedion mostly ignored settlement projects, or treated them as a category that was distinct from architecture, either as urbanism or housing. For example, see *Space, Time and Architecture* (1960 (1940)). There, Pessac is represented through a single building, not a group.

⁷¹⁴ Le Corbusier, *Oeuvre Complete*.

⁷¹⁵ Corbusier, “Maisons En Série,” 1538. The quadrangle was the first morphology Le Corbusier used to develop his Domino System of architectural production. He used an organizational schema from Unwin’s manual to assist him in this work. Unwin did not invent the quadrangle - just like Taylor, or Ford, did not invent the assembly line - rather he invented a system projection that allowed one to move away from that model, while maintaining some of its organizational and experiential qualities.

⁷¹⁶ Ibid., 1538-41. In 1922, he complained that contemporary cities suffered from the reversal of the principles he attributed to Abbe Laugier, having a “maddening variety in the details and a drab uniformity in the overall lines”, or silhouettes, at the scale of the “street and town”; contemporary urban planning was little better than the chaotic fabric of competitive industrial capitalism. In a 1923 article, much of which would later be reproduced in *Urbanisme*, Le Corbusier complained that French urban planners primarily planned “corridors” rather than “rues” or street-places, clearly echoing Unwin’s earlier manual. He contrasted this to a diagram of a rural ensemble which included architectural units, grouped in a more formal arrangement, enclosing a place, and a traffic corridor, following its own functional logic and, potentially, defining an opportunity for visual planning, as distinct from the internal logics of the architectural grouping. “Classement Et Choix,” [Classification and Choice.] *L’Esprit Nouveau* 22(1923). Here he further elaborated on the character of the grouping as pairing “uniformity... reservation, cadence, alignment (as well as) uniformity in detail” with “chaos, tumultuousness in the ensemble” resulting in a “composition of elements rich in contrasts”.

Cité Jardins aux Cretets, May 1914

The *Cité Jardins aux Cretets* project, sited on a parcel on the edge of Le-Chaux-de-Fonds, is an interesting document of the architect's mastery of Unwin's town planning principles.⁷¹⁷ While Le Corbusier had been studying Unwin since 1910, he had still relied on Hampstead or Hellerau as formal models, but as the May 1914 scheme shows, his understanding of the settlement design methods explained in Unwin's manual had expanded, and in this particular case, he focused on a set of techniques Unwin had provided for steeply sloping, south facing sites, like the one he encountered on the edge of his hometown.⁷¹⁸ Unlike the later *Zeilenbau* schemes of the late twenties, which essentially took Unwin's diagram as a plan, to be reproduced, with little or no modifications, here the site conditions of topography, solar and wind orientation, as well as its relation to the existing fabric, are successfully translated into an *individual* town plan.⁷¹⁹ (Fig. 83) Le Corbusier, like Unwin, suggested through a *lotissement*, or "settlement parceling" study, that this more nuanced response to site conditions was economically, as well as aesthetically, superior to the parceling scheme that had initially been prepared for the

⁷¹⁷ This project was never published by Le Corbusier. Bryan Taylor discussed it briefly in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. It was also included in the recent exhibition and catalogue Barry Bergdoll Jean-Louis Cohen, Mardges Bacon, "Le Corbusier: An Atlas of Modern Landscapes," ed. MoMA (New York: MoMA, 2013).

⁷¹⁸ Bryan Taylor included a series of tracings made by Le Corbusier of Hampstead Garden Suburb in 1910, in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. I have discovered the source of these drawings to be Hans Eduard von Berlepsch-Valendas, "Hampstead— Eine Studie Über Städtebau in England [Hampstead – a Study of High City Building in England]," *Kunst und Kunsthandwerk* 12(1909). The extensive article was written by Berlepsch (1849-1921), a Swiss painter who had taught in Munich, alongside Theodor Fischer, the German architect and city-builder whom Le Corbusier had hoped to study with in 1910, before settling on Peter Behrens. Ernst May, Bruno Taut and a number of other important modernist architect settlement-builders all studied with Berlepsch and Fischer.

⁷¹⁹ Illus. 230 "Diagram showing arrangement of groups of houses at right angles to a road to secure a southern aspect." Unwin explained that in "France, where a road runs north and south and it is desired to give the houses a southern frontage, one often sees little rows of houses placed with their ends to the road, access being obtained by a simple pathway." He also used Verona as an example of the same strategy. Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 313-14.

property.⁷²⁰ (Fig. 84) Overall, the scheme resulted in one hundred and ten buildable parcels, situated in order to require minimal excavation and fill, as compared to the seventy afforded by the more rationalistic but less rational rectilinear parceling of the plots.⁷²¹ (Fig. 85) In an accompanying plan-oblique sketch, showing the potential architectural possibilities of the town plan, Le Corbusier turned to Hermann Muthesius' *Kleinsiedlung at Hellerau Gartenstadt*, which he had visited in 1911.⁷²² (Fig. 86) This drawing pointed to a problem acknowledged by Behrens earlier and Lübbert later, namely how to resolve complex visual planning and internal organization efficiently, not only in terms of construction but also in terms of conception, as well as the production of architectural documents. A few months later, Le Corbusier would continue his exercises in Unwinian town planning, but abandon the English domestic architecture language of expression.

Lotissements Domino, December 1914-1916

Le Corbusier's studies for a system of settlement design, projected with the aid of predetermined *standard frames* like a game of Dominos, was prompted by the damage left behind by the rapid German advance through Flanders during the Fall of 1914. The architect's use of this development as a demarcation point in his own career, distinguishing between what came before and what came after the Domino, (1914), has prompted a similar categorization by scholars.⁷²³ In 1922, the Domino work (not yet Dom-ino) was certainly the most dominant part of the article, taking up 6 of the 18 pages entirely.

⁷²⁰ Le Corbusier, "30627 'Etude D'une Cite Jardin Aux Cretets Plan De Parcellement' " (1914).

⁷²¹ "33544 Trace Actuel Du Cadaste Ne Permettant Que 70 Chisaux Contre 110 Environ Avec Le Nouveau Trace," (FLC, May 1914).

⁷²² "30268 Premiere Maquette Pour La Creation D'une Cite Jardin Aux Cretets Plan De Propietarie M Beck," (FLC, May 19, 1914).

⁷²³ *The Marseilles Block*. A recent issue of *Log*, *Log* 30, also deals with the topic. Jean-Louis Cohen, "The Dom-ino Intrigue," *Log* 30(2014). Antoine Picon, "Dom-ino: Archetype and Fiction," *ibid*. There is also a more speculative text by Pier Vittorio Aureli, "The Dom-ino Problem: Questioning the Architecture of Domestic Space," *ibid*.

Initially, it was the various ensembles of units, the settlements or groups of Dominoes that were emphasized, rather than the standard frame itself, which was presented as a small icon-like reproduction of a two-point perspective, prepared in 1915 and originally labeled “standard reinforced concrete frame”. Only after Siegfried Giedion published this icon, in isolation, next to an actual built work, in 1928, treating it as an architectural work in and of itself, did Le Corbusier publish the original perspective drawing, in the *Oeuvre Complete* in 1929, giving it the prominence it still holds today. Before 1929, Le Corbusier’s presentation and use of the Domino was congruent; it was a “frame” used to help manage the architects intellectual work of conceiving a settlement, at the scale of a unit, a kind of scaffold, physical or organizational, to assist in the management of construction, as well as an *order*, like the bays of classical architecture, used to give visual organization to an ensemble.⁷²⁴

First and foremost, for Le Corbusier, the Domino Frame, a *tentative standard* that was not specifically tied to a single dimension or building system, was an instrument used to assist in managing the production of more complex ensembles, as evidenced by the first Domino study, prepared in late 1914.⁷²⁵ (Fig. 87) That study, rooted in one of Unwin’s

⁷²⁴ The use of the standard frame as an order is similar to the diagrams of the Doric order included in Gottfried Semper, *Style in the Technical and Tectonic Arts; or, Practical Aesthetics*, trans. Harry Francis Mallgrave and Michael Robinson (Los Angeles: Getty Research Institute, 2004 (1860/1863)), 766-67. Brooks has shown that Le Corbusier learned various proportioning systems from Peter Behrens, whose own approach is not so different from these diagrams. Brooks, *Le Corbusier's Formative Years*. Auguste Choisy’s own abstracted diagrams of orders also share commonalities with these drawings, Choisy, *Histoire De L'architecture*, 396-98. Choisy’s influence on Le Corbusier is frequently discussed, most recently in Jean-Louis Cohen, "Introduction," in *Toward an Architecture* (Los Angeles: Getty Research Institute, 2007).

⁷²⁵ Le Corbusier, "19141," (FLC). Bryan Taylor has dated this drawing to December 1914. Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. More recent scholarship by Jean-Louis Cohen has shown that the breakdown of these larger Unwinian cells into the smaller reinforced concrete frame bays did not start until March 21, 1915. Cohen, "The Dom-Ino Intrigue." The “definitive” dimensions are dated Oct. 13, 1915. Even these definitive dimensions would change over the next decade, as Le Corbusier finally had the opportunity to move from the atelier to a space of production.

quadrangular organizational schema⁷²⁶, consisted of a site plan, later referred to as a *plan mass*, or “massing plan”, by Le Corbusier, a one-point perspective sketch from the street, and a two-point perspective from the air, or more precisely, taken from the quadrangle designed by George Lucas at Hampstead, albeit as a heavily abstracted mass. (Fig. 88) Like Unwin’s architectural groupings around a *place* and connecting to a street, Le Corbusier’s study broke down the plastic silhouette of the mass organizationally, not yet experientially or constructively, into a series of standard modules. Unlike Unwin or Behrens, Le Corbusier broke down the modules past the dwelling unit scale into a more intricate organizational module, consisting of two variants, the first being labeled “r”, for a row unit, and the second “b”, for a corner unit.⁷²⁷ Eighteen of these frames, or *cells*, as he would later call them, were grouped into three dwelling types, each responding to different conditions along the quadrangle, for a total of nine dwellings. The goal of the system, namely to optimize the “conception of houses in series” for the architect, is made visible by the fact that the right side of the quadrangle is left incomplete, since its resolution is clear. The notation “X” indicated links between paired cells, and likely vertical circulation, whereas blue tick marks

⁷²⁶ Le Corbusier first studied an Unwinian quadrangular organizational scheme in 1910, through a scheme elaborated by George Lucas into the “Houses on Plots No. 112-122”, arranged around a tennis court, for the Garden Suburb Development Co. at Hampstead Garden Suburb, published in Berlepsch-Valendas, “Hampstead— Eine Studie Über Städtebau in England [Hampstead – a Study of High City Building in England].”, the tracing of which was published by Bryan Taylor. This 1914 drawing shows a knowledge not only of Berlepsch’s article but of Unwin’s manual itself, and particularly a series of diagrams, including “Quadrangle of houses with carriage drive circling tennis court, built for the Hampstead Tenants, Limited”, “Pairs of houses arranged round a green”, “Group of large houses with simple carriage drive access” and “Group of large houses with carriage drive circling lawn.” Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 353-55.

⁷²⁷ Unwin usually did not go to this scale of detail, stopping at the unit or cottage scale. In fact there are very few unit plans in *Town Planning in Practice*. The closest drawing to Le Corbusier’s study is “Diagrams showing the simplicity of combined drainage for groups of cottages as compared with separate drainage”, where the internal organization is represented for an entire group. *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 401. Behrens has also shown unit detail in his 1918 studies, but never introduced an organizational scale smaller than the dwelling unit. Conzelman would do something similar in 1917, driven primarily by the existing logic of his constructive system.

indicated dwelling entries.⁷²⁸ The street-level perspective would later be elaborated into a more detailed scheme using vegetation and standard constructive elements, to give scale, as well as to test the efficiency of the design system. However, the key aspects of the system, linking the internal organization of the unit with the visual planning of the ensemble, were already present in the first sketch.⁷²⁹

In the 1922 article, a variant of the quadrangle scheme, dated 1915, was situated on a particular site condition, a bluff, but in no particular geographical location.⁷³⁰ (Fig. 89) This “group of houses in series on Domino Frames”⁷³¹ was presented through two drawings, a two-point perspective and a more detailed plan that replaced the shorthand abbreviations with indications of the standard reinforced concrete frames and vertical circulation. In this case, the number of cells differed slightly and, like the Lucas scheme, Le Corbusier added an exception cell to allow for pedestrian access through the quadrangle and give the previously equal three sides formal hierarchy at the center. The pair of drawings illustrated what the caption explained, namely that a contractor would erect the “rigid frames” on a site already leveled and equipped with simple site-cast piling foundations according to a standard module, as shown in the plan. Following this process,

⁷²⁸ Le Corbusier tested increasing the *enclosedness* of the quadrangle by adding a colonnade, also indicated in the street-level perspective, but not the birds-eye view perspective.

⁷²⁹ That perspective was later published in Le Corbusier, *Oeuvre Complete*, 15-18., simply labeled “Maisons Domino”, or Domino Houses. A slightly altered variant of the same scheme would appear as one of the two illustrations of this system in Le Corbusier’s unsuccessful 1916 patent application, with this grouping of houses in series, around a place, being paired with another grouping, along a street, and again, following one of Unwin’s organizational schema. Le Corbusier, “19215 Pl. Iv,” (FLC, 1916).

⁷³⁰ “Maisons En Série,” 1528-29. A very similar topographic condition existed at Hampstead, something Le Corbusier knew from the published site plans he had traced in 1910. In the 1922 layout, the 1915 scheme was paired with a 1920 scheme, House of Poured Concrete.

⁷³¹ *Ibid.*, 1528. “Groupe de maisons en série sur ossature “Domino.” The same perspective, with the same caption also appears in *Oeuvre Complete*.

the “walls and partitions” could be constructed from available materials, ranging from “lath, brick or concrete block” without “the need for specialized labor”.⁷³²

Also included in Le Corbusier’s 1922 article was a *series of houses, in Domino frames*, grouped around a cul-de-sac or T-junction street.⁷³³ (Fig. 90) Informed by Unwin’s “plan and sketch (one-point perspective) showing on one side the uninteresting vanishing perspective of the unbroken building line, and on the other the more picturesque result of breaks”⁷³⁴, the specific configuration of this grouping of Domino frames had been studied through a series of one-point perspectives.⁷³⁵ (Fig. 91) Through these drawings, Le Corbusier gradually transformed the quadrangle scheme into the street scheme, pushing the modules closer together, extending them deeper and eventually generating more *rhythm* by removing modules from the right side, all the while mindful of the basic internal organization of each unit, as well as the basic logics of the facades. In 1917, he would utilize this basic configuration to develop a “workers city” for a craft in which he himself had been

⁷³² Ibid. He sought to justify the significant amount of reinforcing explaining that in 1915, “the price of steel and cement permitted the significant use of reinforced concrete” as opposed to the postwar period. He would apply the same standard design method to a number of other building systems.

⁷³³ Ibid., 1536-37. This perspective was removed from later editions of the article in *Toward an Architecture*, but reappeared, without the extended caption in *Oeuvre Complete*, as part of the “Les Maisons ‘Dom-ino’ 1914/15” section. The plan of this configuration appears in the 1916 patent application. “19215 Pl. Iv.”

⁷³⁴ Illus. 191. Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 259. (Fig. 49) The same configuration would serve as the basis for Gropius’ first phase at Torton, in 1926, and May’s second phase at Praunheim, in 1927. Both will be discussed in detail in Chapter 5.

⁷³⁵ The perspective studies are actually variants of the earlier one-point perspective sketch, from December 1914. They are also linked to another one-point perspective of a Domino quadrangle, later published in *Oeuvre Complete*, and simply labeled “Maisons Dom-ino”. One of these perspective studies is of the same view, but showing only the basic geometries of the Domino frames (not the reinforced concrete frames), Le Corbusier, “19224 (Untitled),” (FLC, Undated (1915)). Le Corbusier then increased the depth of the quadrangle, creating a space that was more like a cul-de-sac street, in “19225 (Untitled),” (FLC, Undated (1915)). That drawing evolved into the basic ensemble published in 1922, an early volumetric study of which is “19226 (Untitled),” (FLC, Undated (1915)). Here Le Corbusier added shading to the otherwise bare volumes. In addition to the study that would eventually be published, “19221 (Untitled),” (FLC, Undated (1915)), there at least two other variants of this configuration from this period, “30288 (Untitled),” (FLC, Undated (1915)), which includes a mountain landscape and church in the distance, and “19178 (Untitled),” (FLC, Undated (1915)), the first variant where the reinforced concrete frame is expressed on the second level. A variant of this scheme was also included in the 1916 patent application, Fig. 11, “19215 Pl. Iv.”

trained, watch making.⁷³⁶ Planned for a site in northern France, St Nicholas D' Aliermont, Le Corbusier conducted a series of studies of the rural ensembles and housing types of that region. Even though the builder intended to use the heavy timber and brick building systems typical of that region, Le Corbusier applied the same system of architectural production, preparing a series of schemes at the settlement and unit scale between May and June 1917.⁷³⁷ (Fig. 92) It was this experience, one that occurred mostly on paper, but also through negotiations with the client and the contractor, that informed his caption of the street grouping in 1922, stating that the "juxtapositions (of the) two different combinations of the Domino frame", "a", consisting of a frame and a half, and "b" consisting of two and a half frames" would form architectural "groups, streets and places"; the "application of (this) modular construction process", would generate an *aesthetic* of "pleasant harmony" and "cheerfully clear order".⁷³⁸

In addition to the larger-scale groupings around a place or a traffic corridor, generating a quadrangle or a street ensemble, Le Corbusier included a smaller scale grouping of two dwellings that he called the "Maison 'Domino'".⁷³⁹ (Fig. 93) This type was

⁷³⁶ For a general discussion of this project see Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. Also discussed more briefly in Brooks, *Le Corbusier's Formative Years*.

⁷³⁷ All of the schemes are essentially a variant of the Unwin diagram and the Domino Street grouping. Le Corbusier generated multiple settlement schemes, including Le Corbusier, "22392 Cite Ouvriere De St Nicolas D'aliermont Plan De Lotissement Agrandissement a L'est - B," (FLC, 15 May, 1917)., "19323 Cite Ouvriere De St Nicolas D'aliermont Plan De Lotissement Agrandissement a L'ouest - F," (FLC, 19 May, 1917)., "22393 Cite Ouvriere De St Nicolas D'aliermont Plan De Lotissement Agrandissement a L'est Avec Demi Terrain 46 Maisons - H," (FLC, May 19, 1917)., "22394 Cite Ouvriere De St Nicolas D'aliermont Plan De Lotissement Premiere Etape 26 Maisons - L," (FLC, May 19, 1917)., and a final scheme, "22395 Cite Ouvriere De St Nicolas D'aliermont Plan De Lotissement Execution Immediate De 26 Maisons - M," (FLC, 24 May, 1917). He continued to study the ensemble and units through a detailed, one-point perspective, "22398 Untitled," (FLC, 1917)., similar to those done in 1915. At the unit scale, the groups of duplexes also closely resembled some of Unwin's earlier schemes, particularly, Illus. 296 "Group of cottages with a co-operative centre", pg. 381. Only one duplex was realized, in 1918.

⁷³⁸ "Maisons En Série," 1536-37.

⁷³⁹ Ibid., 1531-32. Here it was paired with the Monol Houses, from 1919. In *Toward an Architecture* it would be placed in isolation. In the *Oeuvre Complete*, it would be paired with the quadrangle perspective. The

studied using a similar system of perspectival drawings used for the street grouping.⁷⁴⁰ While this grouping was made up of the same basic frames as the quadrangle and street examples, it included a larger number of frames per dwelling unit, and was arranged around a raised court, with each dwelling having its own roof top garden. The notion of translating housing initially designed for refugees, which made use of constructive systems that had become a kind of vernacular for American industrial workers, for “dwellings of the rich” held appeal for Le Corbusier.⁷⁴¹ Through the smaller scale and the larger personal budget of this hypothetical client, Le Corbusier imagined his first roof top garden, as well as the application of a northern, or ribbon, window.

In addition to the three worked out schemes, Le Corbusier included a fourth “Domino Settlement” plan in 1922, that of a conceptual variation of Unwin’s “groups of

schemes formal expression bares a striking resemblance to an early American concrete house, the Calkins Residence (1911), by Harry Thorne in Indiana. That project was featured, along with Atterbury’s Sewaren House in Sloan, *The Concrete House and Its Construction*. This house possibly influenced Rob van T’Hoff’s Haus in Huister Heide, near Utrecht (1915). Giedion had used that house as a negative example of a concrete architecture, contrasting it with the diagram of the “reinforced concrete skeleton for the Domino Settlement”, which he claimed took full advantage of the formal potentials of reinforced concrete. Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton.*, 84. Giedion is probably to blame for the frequent mislabeling of this perspective and the “maison domino”, when in fact, Le Corbusier never intended for this to be an architectural proposal, but an organizational tool.

⁷⁴⁰ Le Corbusier, "19159 (Untitled)," (FLC, Undated (1915)). This time, the lines of the structural frame appeared in red.

⁷⁴¹ A similar sensibility can be detected in Unwin’s manual, particularly in his discussion of how grouping techniques can accommodate a doctor and his less well to do patients in the same ensemble. Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 300. Both Unwin and Le Corbusier were familiar with the social and compositional theories of John Ruskin, which were often intermingled with geological and botanical models, explaining that “we have to show the individual character and liberty of the separate leaves, clouds, or rocks,” in discussions of how to compose a good “nest of buildings”: “It is a lamentable and unnatural thing to, see a number of men subject to no government, actuated by no ruling principle, and associated by no common affection: but it would be a more lamentable thing still, were it possible, to see a number of men so oppressed into assimilation as to have no more any individual hope or character, no differences in aim, no dissimilarities of passion, no irregularities of judgment.” John Ruskin, *The Elements of Drawing: In Three Letters to Beginners* (New York: Wiley & Halstead, 1858), 119-20.

buildings designed to maintain square roof lines on a curving road".⁷⁴² (Fig. 94) This scheme was one of five studies investigating the application of the Domino System to more idiosyncratic sites, all of which included scales of resolution from the architectural group to the street and the place. Only the published variant included indications of the frame elements.⁷⁴³ (Fig. 95) All of these studies of the Domino System were based on organizational schemes included in Unwin's 1909 manual; they served as surrogates for real *translations from drawing to building* until the establishment of the Bordeaux laboratory, in 1924.

Lacking opportunities to work directly with the already established standards of the *concrete town* vernacular until 1916, Le Corbusier turned to manuals describing these systems, such as *The Concrete House and Its Construction*, and to the advertising material describing these new building products and systems.⁷⁴⁴ (Fig. 96) He would add these parameters, at the micro scale, to the macro scale parameters provided by Unwin's manual, to further refine his standard method for settlement design, the Domino System. Standard bricks, concrete and ceramic blocks, as well as reusable formwork, directly informed his

⁷⁴² Corbusier, "Maisons En Série," 1534. Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 346. Another scheme that is even more similar to Unwin. Le Corbusier, *Oeuvre Complete 1910-1929*, 26.

⁷⁴³ All four schemes would later be published in *Oeuvre Complete*, indicating the architect's continued belief in their relevance. *Oeuvre Complete 1910-1929*. In this publication, he chose to show a number of themes as sketches, even though all of them had been carefully projected in detail, to study how the standard frame would work at the settlement scale, as well as in various parcel, traffic and typological conditions. These conditions, as well as the basic organizational solutions could all be found in *Town Planning in Practice*. A few also draw on Sitte, "Improvements in the Modern System."

⁷⁴⁴The Villa Schwob, located in La Chaux-de-Fonds, commissioned in 1912 and completed in 1916, was Le Corbusier's first use of a reinforced concrete frame, the lost-tile process floors and block infill. Ozenfant would write a review of the project, under the pseudonym, Julien Caron. In this article, a photograph, showing the construction site of the project, was the first publication of the frame as an organizational device and a material artifact. Julien Caron (Ozenfant), "Une Villa De Le Corbusier," *L'Esprit Nouveau* 6(1921). (Fig. 97) Allan Brooks has written about this project, as well as Le Corbusier's work at SABA, motivated by this experience. Brooks, *Le Corbusier's Formative Years*. Brooks, as well as Bryan Taylor and Francesco Passanti, have pointed to the importance of *The Concrete House and Its Construction*.

studies of the Domino frame's dimensions, as visible in a set of drawings from October 1915.⁷⁴⁵ (Fig. 98) Through a series of parallel studies at this time, standard furniture, as well as standard windows and doors, further informed the frame.⁷⁴⁶ (Fig. 99) Le Corbusier alluded to these studies in 1922, stating that the "height between the slabs was coordinated with that of the doors, transoms, cabinets, window frames, all to a common modules, they fit together exactly."⁷⁴⁷ The resulting dimensions of his "definitive" Domino frame were not driven by a rationalist interest in structural or material properties of the reinforced concrete itself, as Giedion would later claim, but were instead the byproduct of a series of more quotidian dimensions of products, that had been developed through the more irrational *competition* between various entrepreneurs.⁷⁴⁸ This may explain why Le Corbusier, quite in contrast with the tenets of structural rationalism, showed little interest

⁷⁴⁵ Le Corbusier, "19190 (Untitled)," (FLC, October 7, 1915). In this drawing, Le Corbusier included a sketch of how standard ceramic or concrete block infill would work with the reinforced concrete frame dimensions he was developing, dimensions he had also tested at the unit scale and the settlement scale. Compare to Fig. 36, "Arrangement of concrete and hollow splayed tile" in Sloan, *The Concrete House and Its Construction*. Here, Le Corbusier is already using the final designation of his three frame types, type A, B and C, which were also used in the 1916 patent application. The sketches of the standard building components do not appear in the revised set of dimensions in Le Corbusier, "19191 (Untitled)," (FLC, October 13, 1915). These drawings are also included and discussed in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁷⁴⁶ Le Corbusier made dozens of studies of this topic. A few typical examples include studies of the standard block infill, Le Corbusier, "19135," (FLC, Undated (1915)), "19136," (FLC, Undated (1915)), "19138," (FLC, Undated (1915)), and "19139," (FLC, Undated (1915)), studies of standard furniture, in relation to standard block infill, "19147," (FLC, Undated (1915)), and studies of standard windows and doors in relation to the block infill, such as "19151," (FLC, Undated (1915)), and "19152," (FLC, Undated (1915)). These drawings are comparable to two photos from, Sloan, *The Concrete House and Its Construction*. (Fig. 77) "Method of Securing Window Frames During Wall Construction" and Fig. 78 "Pouring Concrete Into a Column Form". In 1922, Le Corbusier presented these studies through an elevation and interior of Domino Houses. Corbusier, "Maisons En Série," 1534-35. By 1929, after Giedion reinvented Le Corbusier as an expert in reinforced concrete construction, he added more detailed studies of the reinforced concrete frame. Le Corbusier, *Oeuvre Complete*, 15.

⁷⁴⁷ Corbusier, "Maisons En Série," 1535. Cohen 263. In Cohen, *exactement* is translated as "perfectly". Here the emphasis is more on tolerances than on ideal dimensions or proportions.

⁷⁴⁸ "Des Yeux Qui Ne Violent Pas... Iii: Les Autos." I have already discussed Le Corbusier's admiration for the irrational market forces that drove the standardization of industrial products, after their more rational establishment, through analysis, experiment and organization, in Chapter 1.

in exposing the reinforced concrete frame directly, instead alluding to it through layers of material assemblies, just as Behrens had done in his factory work.⁷⁴⁹

While Le Corbusier made no direct reference to Taylor, Taylorization or *Taylorisme*, until 1917, his own thinking regarding the construction of the Domino System, by low or even unskilled laborers, and his treatment of the frame, as a scaffold for further work, is very similar to the organizational logics of Gilbreth's work at this time. Le Corbusier's sketches of temporary steel formwork, built to assist in the casting of the floors using a lost-tile process, would transform the frame into a kind of scaffold for the further installation of prefabricated concrete or ceramic block infill, windows, and doors.⁷⁵⁰ (Fig. 100) The most direct source for this procedure was *The Concrete House and Its Construction* (1912)⁷⁵¹, rather than Gilbreth's scaffolds or route models, which were published in France in March 1914.⁷⁵² Le Corbusier's own architectural production would become much more similar to Gilbreth's route modeling during his work at Bordeaux, which I will discuss later in this chapter. In many ways, the former bricklayer's apprentice and the former watchmaker's apprentice shared a similar source to their management of construction of reinforced concrete frames, the heavy timber construction of the Middle Ages, visible in

⁷⁴⁹ Allan Brooks has shown that Le Corbusier learned his particular regulating lines technique from Peter Behrens. Brooks, *Le Corbusier's Formative Years*, 239.

⁷⁵⁰ FLC 19136.

⁷⁵¹ Rooted in the basic principles of the Hennebique System, the American approaches included in the manual had eliminated much of the need for skilled carpenters by simplifying the structure and constructive logic by purging much of the intricate formwork and optimizing the system for low to mid-rise residential structures. After the construction of a foundation, simple, rectilinear, form work for the columns was erected, or alternatively, the columns could be cast on site and then tilted up, before being shored and linked by wooden scaffolding, which would hold them in place and support the formwork for beams, additional reinforcing and hollow splayed ceramic tile. Once this mélange of materials was in place, concrete would be poured, fusing the structure into a monolithic frame. Window and doorframes sometimes helped reinforce the scaffolding and could act as the formwork. As the description indicates and the photographs attest, this constructive system was much more primitive than the three fabrication and assembly systems developed by Atterbury, Conzelman and Harms Small. Le Corbusier was after contemporary conventions.

⁷⁵² Henri Louis Le Châtelier, "Le Système Taylor," *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* 113(March 1914).

illuminations.⁷⁵³ (Fig. 101) Their real innovations came in the form of information technology, in instruments of control and feedback, not in the constructive systems themselves.

Le Corbusier's interests in finding problems, not only solutions, and in organization, more than fabrication, manual or mechanical, is evidenced through two other projects which would later be incorporated into the "Houses in Series" discussion. At the unit scale, Le Corbusier finally added a freestanding house, the Maison Citrohan (1921), to his studies of groups, ranging from 18 units to the duplex Maison Domino; here the same architectural production methods were demonstrated through a project intended to be constructed using a different building system.⁷⁵⁴ At the ensemble scale, he expanded to a City of Three Million, the number being a direct reference to the earlier unit of Garden City Planning, 30,000; here he sought to demonstrate that his ability to design at the scale of the unit and the settlement could also be expanded to deal with the scale of the entire city.⁷⁵⁵ After the publication of "Houses in Series" in (1922), Le Corbusier began work on his first group of houses, the Villas Roche-Jeanerette, in Paris. While that project allowed him to apply many

⁷⁵³ A good document of this building tradition is the "Construction of Noah's Ark", (British Library, 1410-1430). Le Corbusier's first house project, the Villa Fallet (1906) was built the same way. Le Corbusier organized the work of raising the heavy timber frame, executed by the young architect and other students, while Le Corbusier himself design and applied the ornamental treatment onto the stucco façade. Brooks, *Le Corbusier's Formative Years*.

⁷⁵⁴ Corbusier, "Maisons En Série," 1539. Le Corbusier would continue to use this project to present the evolution of his architectural production system, with variants produced from 1923 until 1926. These were included in Le Corbusier, *Oeuvre Complete*. The Maison Citrohan was not only a reference to the car chassis but to the particular cars used to train the evolution and adaptation of the 1920 "Eyes That Do Not See".

⁷⁵⁵ The City for Three Million was added to the "Houses in Series" article in *Toward an Architecture*. Le Corbusier, *Toward an Architecture* (Los Angeles: Getty Research Institute, 2007). For more on this project see Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier*. Francesco Passanti, "The Skyscrapers of the Ville Contemporaine," *Assemblage* 4(Oct. 1987). The Immobile Villas included here would eventually turn into the units of the Unite.

of the ideas that he had been developing for much of the last decade⁷⁵⁶, it was this series of experiments at Bordeaux that generated new ideas about the nature of architectural production.

The Series of Experiments at Bordeaux, December 1923- May 1926

The *Quartiers Modernes Frugès*, or QMF, was Le Corbusier's only constructed settlement project of the interwar period, occupying much of the architect's attention, and publications, from 1923 until 1929. In 1926, the architect would refer to it as his "laboratory of industrialization, standardization and Taylorization". In 1928, Siegfried Giedion would use this project as the primary model of a new aesthetic quality of "RELATION and INTERPENETRATION", which he would later refer to as the "space time" qualities of modern architecture.⁷⁵⁷ A series of errors, of which some, but not all, were attributable to the architect, led to only a partial completion of the settlement, in May 1926, and a delay in that portion's settlement, until 1929. Le Corbusier would compare the troubled project to a Balzac novel, with a crooked contractor fulfilling the role of a villain and his client and partner in the process, Henri Frugès, acting as the tragic hero. The simultaneous importance given to this project and its tragic end help explain the unique presence of QMF in *Toward an Architecture*, starting in 1924, *Urbanisme* (1925) and the *Oeuvre Complete* (1929) as something that was neither an un-built project nor a completed work. It may also explain why there has been relatively little scholarship on this project since Giedion's article in 1928.

⁷⁵⁶ The Villas Roche-Jeanerette began with a series of studies that drew heavily on Unwin's organizational schema. For example, Le Corbusier, "15102," (FLC). Here, he would also organize a system of standard window sizes, an approach that I will discuss at the end of the chapter.

⁷⁵⁷ Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton. Space, Time and Architecture*.

The only book length study, Phillippe Boudon's *Pessac de Le Corbusier: 1927-1967* (1969) focused more on the transformations made to the project after 1929, than the project itself, letting Le Corbusier speak primarily through a lengthy speech from the premature opening, in May 1926, and Henri Frugès, who was still alive in 1967, speak through an interview.⁷⁵⁸ The work in Bordeaux was also extensively discussed in the catalogue accompanying an exhibition held at Harvard University, in 1972, by Bryan Taylor. In his extensive history of the project, Taylor praised Le Corbusier and Pierre Jeanneret's agility, flexibility and general preparedness "to rework standard plans when practical necessities intervened or even when, at times individual, local, or regional tastes presented themselves".⁷⁵⁹ He also points to the significant impediments to the project, caused by a truly incompetent contractor and a hostile municipal building department, as key causes for the projects partial completion. He nevertheless concluded that while Le Corbusier was not entirely at fault for the project's problems, and could even be commended for handling a difficult situation, his claim of Taylorization was false, because the architect was in "no position at the time of Pessac to control the Taylorization of any production of building materials or of a building site as he would have liked" and that "(n)either an efficient, taylorized system of planning nor industrialization of the construction site was achieved", as demonstrated by the project's failure to achieve efficiency in terms of "time and cost".⁷⁶⁰ I will challenge Bryan Taylor's characterization of Pessac by more clearly defining two related issues, first, what constituted the Taylorization,

⁷⁵⁸ Philippe Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale* (Paris: Bordas 1985 (1969)). The first edition is translated as Philiippe Boudon, *Lived-in Architecture: Le Corbusier's Pessac Revisited*, trans. Gerald Onn (London: Lund Humphries, 1972).

⁷⁵⁹ Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁷⁶⁰ Ibid.

or more specifically the scientific management of production, according to Taylor and Le Corbusier, and second, what type of production was being scientifically managed.

As I have clarified in Chapter 1, scientific management is distinguished from other forms of modern industrial management by the application of the laboratory method and a focus on the production of tentative standards, through experimentation and standardization within the space of production; while there is certainly a promise of overall efficiency, as well as social equilibrium, the primary criteria is an ontological one. QMF, or for that matter, Bethlehem Steel, may not be an example of systematic management, but if novel standards were derived, then it is an example of scientific management, or at least the laboratory method.⁷⁶¹ As demonstrated in Chapter 2, many of the most influential *products* of a scientifically managed space of production were actually projection instruments and methods, such as the Gantt chart or the route model. The laboratory method required not only an engagement with the mental space of the manager, but with the physical and social space of production. Le Corbusier, like Frank Gilbreth, certainly felt obliged and responsible to his client, and friend, Henri Frugès, to maintain an economical laboratory, but as he made clear to Frugès, economical efficiency, even profit, would only come after experimentation and standardization, following the completion of laboratory work. Bryan Taylor is partially correct in arguing that Le Corbusier was not in an ideal position vis-à-vis the contractor he worked with, as he lacked basic skills, such as site surveying or cost estimating, however, it did not prevent Le Corbusier from applying, and further standardizing, his own management system for architectural production. Le

⁷⁶¹ As David Nelson has shown, and as I have also argued in Chapter 1, Taylor was not successful, despite his later claims, at installing systematic management at Bethlehem Steel. But regardless of that failure and his false claims, he did practice the laboratory method and through this approach, he standardized his high-speed tools, as well as aspects of scientific management itself. Gantt would also develop the Gantt chart there.

Corbusier had certainly hoped to use QMF as an opportunity to further standardize his architectural production system in relation to the standards of American industrialized settlement building, but unlike Grosvenor Atterbury, George Harms and Henry Small and John Conzelman, he never claimed to be applying the laboratory method for the purposes of experimentally deriving and standardizing new methods of fabrication and construction. Instead, he had hoped to develop new modes of architectural production, around what he believed to already be conventional construction methods, albeit in America and not in France. His already partially standardized architectural production system, developed primarily in the atelier, would prove to be impressively agile in coping with the numerous difficulties, generated by his incompetent contractor, as well as at incorporating feedback from Frugès and potential clients.

Utilizing Philippe Boudon's primary documents and Bryan Taylor's existing research of the primary instruments and products of Le Corbusier's work at the QMF, namely architectural drawings, I will reassess the laboratory work in Bordeaux, not only at Pessac, but also in two earlier projects, the Maison Du Tonkin and Lège, through the lens of a more specific understanding of what industrialization, and more specifically standardization and Taylorization had constituted for the architect. I will first provide an overview of the framing of the laboratory work in Bordeaux. Then I will follow the "series of experiments" from December 1923 until the fall of 1926. I will finally conclude with a few examples of what Le Corbusier himself had viewed as the products of this laboratory work, between 1926 and 1929.

Staging the laboratory at Bordeaux

In December 1923, Henri Frugès contacted Le Corbusier, after seeing publications of some of his work, in order to prepare a proposal for a dozen units of workers housing near his father's lumber mill, in the town of Lège-Cap-Ferret, situated on France's Atlantic coast, 50 kilometers due west from Bordeaux.⁷⁶² Le Corbusier could have chosen, much like Peter Behrens had done five years earlier, to build a demonstration of his equivalent of the grouped building system. Instead, as Le Corbusier would later claim, he convinced the young industrialist to stage a "series of important experiments", which he hoped would result in a system of standardized housing delivery that the architect could apply to his own work, for "housing for the rich and for the poor", and that Frugès and his family could use to build speculative workers towns throughout southwest France. In other words, Frugès and Le Corbusier were both invested partners in laboratory work, which would only yield them results after experimentation and standardization was complete. Although Le Corbusier would prepare initial designs for units to be used at Lège as early as December 15, 1923, the first site plan for that group of houses in series would not be drafted until August 2, 1924. By that time, Le Corbusier had convinced Frugès that it was necessary to conceive, construct and have someone dwell in a tentative standard, the Maison du Tonkin in Bordeaux proper, which was nearly completed, by the time the architect had drafted the first settlement scheme, consisting of nearly 150 cells, for another site owned by the Frugès family, at Pessac, a suburb six kilometers southwest of Bordeaux center. By late July, the Bordeaux projects already constituted a form of laboratory work; tentative unit types, which had been developed for Lège were being tested, at a scale of

⁷⁶² This initial meeting is discussed in an interview with Frugès in Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*. Bryan Taylor draws heavily from this interview in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

one-to-one, through the construction of the Maison du Tonkin, and were simultaneously tested at the settlement scale through the Pessac parcel. This laboratory work would continue, synchronously, for the next year on all three sites, and would be conducted diachronically, within Pessac, for the following year. During this process, Le Corbusier's own architectural production system proved efficient and generative, in spite of some of his collaborators and with the specific assistance and inputs of others.

While Henri Frugès did not “authorize him to fully break with all conventions”, as the architect would later claim, he was certainly a willing and active collaborator in Le Corbusier's laboratory work. He matched Le Corbusier's enthusiasm for new construction equipment, such as the Ingersoll-Rand Cement Gun, or new building products, such as large windows, and even displayed his own interests in technology by inventing some appliances unique to the settlement.⁷⁶³ He assisted Le Corbusier's design of the roof gardens by identifying local species that would do well in the given conditions.⁷⁶⁴ Sharing an interest in painting with the architect, and also responding to potential clients' desires for an individuality of the units, Frugès encouraged Le Corbusier to experiment with a polychromic system, at the urban scale.⁷⁶⁵ He also balanced Le Corbusier's interest in

⁷⁶³ Frugès insisted on amenities, such as hot and cold running water, electricity and a shower of his own invention, none of which were typically included in housing, certainly not mass housing, in this part of France. Interview in Boudon.

⁷⁶⁴ Frugès selected, financed and even oversaw the planting of native vegetative species to line the public spaces of the settlement, deferring to Le Corbusier for the spatial organization. Interview in Boudon.

⁷⁶⁵ Frugès was not only an industrialist, amateur inventor and first-time developer, he, like Le Corbusier, was also an amateur painter. He also conducted polls, using models provided by the architect, of which types might be of most interest to potential clients. This prompted a shift from the architect's vertical garden city preoccupations, which would have made little sense on this site, and generated a mix of types, much more similar to what was offered at Hampstead, but one that was nevertheless still more dense than what was found in interwar French “garden cities”, which were actually much more similar to American suburbs. For a discussion of interwar French “garden cities” see Françoise Choay, *The Modern City: Planning in the 19th Century* (Brazillier, 1969).

developing a more “vertical garden city”⁷⁶⁶ with the real desires of potential clients, who preferred single family houses, and also encouraged the consideration of post occupancy assessments from the residents of the Maison du Tonkin and Lège, inputs that the architect incorporated into the project with relative ease.

Frugès also introduced two other collaborators to the project, both of whom had worked with his family in the past, Mr. Vrinat, the engineer who would oversee the fabrication of many of the building components used in construction and occupation, including formwork, as well as windows and doors, and Mr. Poncet, the local contractor who would oversee the construction sites of the Maison du Tonkin, Lège and the first few structures at Pessac. Mr. Vrinat proved to be a capable ally, working directly from Le Corbusier’s own drawings and often making improvements. Frugès impetus in hiring Mr. Poncet, instead of the Parisian contractor recommended by Le Corbusier, was to not only save money but, more importantly, to quell animosity from the local community, particularly the building department. This proved to be a major mistake, as he would later acknowledge, one that “delayed the (construction) work for whole year”.⁷⁶⁷ Poncet’s faulty surveying and permit submission would also contribute to the municipality’s decision to withhold basic utilities for three years, preventing the sale of the units. While Le Corbusier

⁷⁶⁶ By 1922, Le Corbusier had become increasingly critical of France’s interpretation of the Garden City movement and felt that the same basic principles could be achieved at a higher density and larger scale, as shown in his more speculative proposal for a City of Three Million. His studies for “immobile villas” imagined a “vertical” instead of a “horizontal garden city”, a proposition he argued for using Unwin’s own methodology and early perimeter block schemes. Instead of the relatively large individual parcels of 400 m², of which only 50 or 100 m² were allocated for the building plot and the rest for lawns or gardens, the architect proposed dividing the dwelling and garden equally, at 50 m² each, and potentially elevating these spaces 6-12 meters above the ground. Additionally, cooperatively owned spaces for agriculture and sport, 150 m² per inhabitant, would be clustered nearby, and professionally managed, by a specialist. With the exception of the verticality, this type of organization was already advocated for and realized at Hampstead Garden Suburb, but had not been followed in many of France’s *Cité Jardins*. From the outset, Frugès insisted that an increase in density and verticality be balanced with the desires of the potential clients for single family, duplex or row house types, resulting in a more heterogeneous mixture similar to Hampstead.

⁷⁶⁷ Interviews Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*.

was certainly the primary advocate for purchasing the costly cement gun, it was also Poncet's faulty cost estimates that reinforced the promises of the Ingersoll's advertising of guaranteed economical efficiency and their product's ease of use.⁷⁶⁸ The removal of Poncet, as well as the cement gun, from the constriction site, and the arrival of Mr. Summer, the Paris-based contractor that Le Corbusier had initially recommended, in May 1925, brought efficiency to an already productive space of inquiry, but it could not rectify the lost capital nor could it prevent the three-year utilities embargo, a manifestation of the animosity that hiring Poncet was supposed to prevent. While Summer did not seem to utilize the kind of advanced project management tools used in American contracting, Le Corbusier's own management tools, informed by what he saw in the publications on scientific management, proved exceptionally agile at shifting from one building system to another, responding to client demand and even accounting for Poncet's poor site survey, by adjusting the already complex artifact, at the scale of the settlement, the unit and the building component, in space and time. Although these difficulties certainly limited the scope of "engineering research" in Bordeaux, they were key in pushing Le Corbusier's "architectural research" in unplanned, but nevertheless managed, directions, and also contributed to the emergence of a "novel (and) unexpected aesthetic".⁷⁶⁹ This architectural research was not only

⁷⁶⁸ Bryan Taylor has used Le Corbusier's faith in this equipment both as a reflection of "true 'taylorizing' fashion", a "clear case of the technique, the machine, guiding the decision making of the man" and as proof that the architect didn't really comprehend industrial management, since he had had Frugès purchase the wrong tool for the job. Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. Bryan Taylor's first observation reflects a general confusion between the role of the manager and the operator; the role of the modern manager, particularly the experimenter, was tasked with developing a technique for organizing the use of machinery by a human operator, precisely because one had not been defined. While Le Corbusier's faith was certainly too high, his decision to organize a laboratory in order to define techniques with which a particular developer, Frugès, and a particular contractor, Poncet, would later work, as opposed to simply specifying manual or mechanical work, is fully in line with the principles of scientific management.

⁷⁶⁹ Le Corbusier, Speech at Pessac, June 13, 1926. In Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*.

“conditioned by the imperative of construction” or the interest in inducing “primal sensations” through the play of “architectural volumes”, it was focused on discovering a set of methods and parameters for the projection of houses in series in space and time.⁷⁷⁰ As a direct result of his work at Pessac, by 1928, Le Corbusier would claim to have discovered a third mode of production that was neither simply “architecture” or “urbanism”, but was instead the “logical study of the cell and its functions relative to the ensemble”, a method that furnished a “solution rich in consequences”.⁷⁷¹

Establishing the Standard: The Ribot House and the Lège Types A and B

The laboratory work in Bordeaux was initially based on an established standard, developed by Le Corbusier in late 1923, the Ribot House⁷⁷², after the subsidized housing program in France, the Ribot Law.⁷⁷³ Here, it was legislative parameters, and not those of the industrial production or products, that would serve as the tentative standard. The basic organization of the unit followed the earlier Domino studies, as well as the Maison Citrohan, consisting of a reinforced concrete frame, masonry infill shear walls, as well as thinner lathe supported stucco membranes, capable of being sprayed with a cement gun. The unit, which was elevated by two shear walls, contained a fairly open ground floor on the first raised level and two bedrooms and a bath on the second level. Vertical circulation was pushed out of the main body of the structure, with a main entry on the side and additional access to the ground level garden, bedrooms and a rooftop terrace provided by a

⁷⁷⁰ Ibid.

⁷⁷¹ Revised “Mansions en Serie” added in 1924 to *Toward an Architecture*, included in Corbusier, *Toward an Architecture*, 277.

⁷⁷² The Ribot House was published in an issue of *L'Architecture* (December 1923), with these published drawings included and briefly discussed in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. According to FLC, the original drawings have been lost.

⁷⁷³ The Ribot Law, passed in 1908, provided government funds to *societies*, or “building societies”, similar to those in Germany and England, for the construction of affordable housing. Discussed in *ibid.*

second exterior stair. This scheme served as a departure point for discussions between Le Corbusier and Frugès in December 1923. By December 15, Le Corbusier had prepared two new variants of this tentative standard, intended for Lège.⁷⁷⁴ (Fig. 102) Both unit variants were designed around a new cell of 5 meters, measured from center to center of the reinforced concrete frame, instead of the 4 meters used in the earlier Domino studies, and were set atop shear walls, over a garage. Type A consisted of a single elevated story of two cells, while Type B consisted of two elevated stories of a cell and a half. The external circulation had been significantly reduced to a single stair leading up to both Types, although Type B contained an internal stair from the living to the bedroom level. Within Le Corbusier's more detailed drawings of both types, his intent to use a lathe and sprayed on cement technique for all of the wall enclosures, standard prefabricated window assemblies, and the load bearing reinforced concrete frame, is clearly indicated.⁷⁷⁵ (Fig. 103) In contrast to the earlier Domino studies, where standard cells were conceived of as open systems that could assemble into various groupings, at the scale of a quadrangle, street, or duplex, these types were conceived of as closed systems⁷⁷⁶, like the Maison Citrohan, as well as the studies for "Houses in Series for Artists" and "Houses in Series for Craftsmen",

⁷⁷⁴ Le Corbusier, "20785 Facades Type a Et Type B," (FLC, 14 December 1923). "20796 Type a Et Type B (Plans)," (FLC, December 1923). Included and partially reproduced in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁷⁷⁵ A similar technique was published in *Industrial Houses of Concrete and Stucco: A Survey of the Principal Types and Groups of Permanently Constructed Industrial Houses*, (New York: The Atlas Portland Cement Company, 1918).

⁷⁷⁶ Tom Peters defines "closed systems", as systems in "which form and structure are two aspects of a single design process. Closed systems are simple to understand, but they cannot easily adapt to different uses. Open systems are more flexible. They result from two levels of design: first the design of the structural system and then the design of the building form. Such structural systems can be put together in many different ways to make different buildings. But this also makes them more complex to design, because the system has to accommodate many configurations that may not all have the same characteristics. Their connections have to satisfy criteria that are only completely known when the formal design is complete. Therefore, open-system elements are ideally designed to be stiff in and of themselves, so that they do not need secondary stabilizing mechanisms. Two factors supported the development of the open system: component manufacture and system logic." Tom F. Peters, *Building the Nineteenth Century*: (Cambridge: The MIT Press, 1996), 221.

developed during this period.⁷⁷⁷ (Fig. 104) Like those un-built projects, Le Corbusier made perspectival studies of the units intended for Lège in series, considering how their arrangement as free standing objects might still define common spaces and ensure privacy, but they were not intended to be physically grouped.⁷⁷⁸ (Fig. 105) This same study already reflected the general flora of the particular site, a pine forest, and considered how the particularities of the specific, such as the contrast between the furniture and tools owned by the rural-industrial workers against the more abstract “cubes of air”, as Giedion would later refer to Le Corbusier’s spaces, would contribute to the character of the general system.⁷⁷⁹

Experimental Derivation through construction: The Maison du Tonkin

Much like Atterbury, Harms and Small, and Conzelman, Le Corbusier chose to extend the establishment of his standard, from analysis to experimentation, by constructing an experimental house, the Maison du Tonkin. (Fig. 106) The architect convinced Frugès to build this “small house”, which “stood at the beginning of a series of important experiments”, during the month of July, in 1924, on an infill site in Bordeaux.⁷⁸⁰ The project was an evolution and adaptation of the Lège Type A, and the “first ... house, to be made completely by means of a cement gun”, with a 6-8 cm corrugated skin of cement,

⁷⁷⁷ There is a series of studies, in plan and perspective of groups of houses in series, between 1922 and 1924. They include: “Maison Citrohan, Villa en serie” (1922), actually two Maison Citrohans, rotated so as not to be repetitive, “Maison ouvriere en serie” (1922), at least five visible units, all rotated so as to create variety in the ensemble, and “Maisons en serie pour artisans” (1924), four units, also designed to be grouped. They were added to *Toward an Architecture* in 1924 and in the first edition of the *Oeuvre Complete* (1929).

⁷⁷⁸ The perspectival study of the Lège Types, Le Corbusier, “20784 6,” (FLC, Undated (1923?)), is similar to the other studies of the houses in series at this time, but was not included in *Vers une Architecture* (1928) or the *Oeuvre Complete* (1929).

⁷⁷⁹ Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton*. The cube of air, literally the clear span between the frames, as opposed to the dimension from center to center, would eventually become dimensionally standardized, or normed, during the construction of the Maison Du Tonkin in July 1924.

⁷⁸⁰ The project was included in the first edition of the *Oeuvre Compete*, as well as the first German translation, in 1930, but was later removed. Le Corbusier, *Oeuvre Complete*, 68.

sprayed on lathe and enclosed on the interior by wood and stucco, serving as the primary membrane.⁷⁸¹ This important experimental house generated the basic dimensions of the reinforced concrete frame, now set to a five meter clear dimension as defined by the window assembly, as opposed to earlier Domino studies, where various mass produced product dimensions had informed the frame dimensions, measuring four meters from center to center of reinforced concrete column.⁷⁸² Despite the “incompetence and dishonesty” of the local contractor during construction, Le Corbusier believed that with the continued “confidence Mr. Frugès had given him”, these experimentally derived standards could be applied to “houses in series”.⁷⁸³ According Le Corbusier’s own laboratory work theory, he had identified an *established* standard, around 1915, as part of his Domino studies, and now he had *fixed* that standard for his work at Bordeaux, before beginning the standardization work on his overall system of architectural production, at the scale of the settlement and the building component, simultaneously. By the summer of 1925, he would also present his newly standardized system to the window manufacturers of France, appealing to them to now define a module for windows; this time, instead of representing his module as a frame, as he had in the 1922 article, he presented it as a void between frames, a change in his evolving system that reflected the work done at Bordeaux.⁷⁸⁴ (Fig. 107)

Experimental Derivation through Projection: *Lotissement Pessac*, Initial Study

⁷⁸¹ Ibid.

⁷⁸² Bryan Taylor has discussed this shift in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. Due to his own understanding of Taylorization as nearly synonymous with mechanization, B. Taylor sees the production in smaller series of these windows as somehow not industrial. In fact, since this was experimental work, *premature standardization* through the definition of a fixed standard, would have made little sense.

⁷⁸³ Le Corbusier, *Oeuvre Complete*, 68.

⁷⁸⁴ Corbusier, "Appeal Aux Industriels." Republished in Le Corbusier, *Oeuvre Complete*, 77. Here Le Corbusier used the same graphic language as in his unpublished perspectival Domino studies, such as Fig. 93.

Before turning his attention to Lège, Le Corbusier used his new five-meter module, to prepare the first settlement study for Frugès' larger parcel at Pessac.⁷⁸⁵ (Fig. 108) Dated July 25, 1924, that drawing marked a return to the more synthetic open system planning of the Domino Studies, which investigated groups of cells, clustered to form single family, duplex, row house units, as well as streets and places around three basic traffic corridors.⁷⁸⁶ In addition to the abstract cells, laid out according to Frugès' sense of consumer demand for single family homes, and Le Corbusier's self taught town planning principles, the sheet included sketches of construction details of the experimental work at the Maison du Tonkin. These sketches demonstrated the architect's growing confidence that, with his emerging architectural production system, he could now simultaneously project at the scale of the pre-modern urban unit, the town or village, and at that of the industrial product, formwork, or window, in space and time. This first settlement scheme was used less as a definitive proposal and more as a game board, on which a *match* would be played. While Le Corbusier and Frugès had already had some problems with Mr. Poncet, the project's contractor, in constructing the Maison du Tonkin, they were not yet fully aware of the extent to which he would be their opponent in this game. To make the match even more difficult, the *game board* itself had been set incorrectly, due to serious errors in

⁷⁸⁵ For a brief history of the site see Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. Frugès also discussed it in his 1967 interview, reproduced in Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*.

⁷⁸⁶ The scheme drew on the earlier Domino studies, as well as on the *Cite Ouvriere de St Nicolas D'Aliermont*. Here there is also use of Unwinian organizational schemes that had not yet been studied in the 1914-15 works. The western half seems clearly informed by Illus. 281 "Groups of small gardens designed to produce some total effect." Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 358. The choice of a traffic corridor centered scheme to the east and allotment garden interior block centric scheme to the west also echoes two diagrams used by Hermann Muthesius to denote the two basic types of suburban "small settlement" types. Since Pessac was to be a laboratory, Le Corbusier may have wanted to make sure to cover this spectrum. Those drawings were included in the 1918 and definitive 1920 editions of Hermann Muthesius, *Kleinhaus Und Kleinsiedlung*, 2nd ed. (Munich: F. Bruckmann, 1920).

the survey. These errors would turn into *difficulties*, and these difficulties would simultaneously turn into *picturesque beauties*⁷⁸⁷, and serious economic and bureaucratic problems over the following year.

Standardization through Conception, Construction and Dwelling, Lège, 1924

Only after the construction, and settlement, of the experimental house in Bordeaux, and the testing of the newly derived tentative standard cell, at the scale of a much larger settlement, did Le Corbusier prepare a settlement scheme for his original commission, the “*Lotissement de Lège*”.⁷⁸⁸ (Fig. 109) Originally dated August 2, 1924, it included a layer of modifications made in pencil some time later that month, before the final documents were submitted to the building department, in September, and fabrication and erection started, in October 1924.⁷⁸⁹ The initial August 2 scheme included three Type A units, three Type B units, as well as a small hostel to house single workers temporarily. Somewhat incidentally, this massing plan also served as a kind of construction plant plan, for Frugès’ lumber mill, where the formwork, window frames and other cabinetry would be fabricated, which was located immediately adjacent to the future settlement and indicated by the label “hanger” in the settlement scheme. Following Unwin’s principles of town planning, Le Corbusier first defined a small communal center, set as far away from the lumberyard, as well as the main road to the south, as possible. Two of the traffic arteries simply emerged from the triangular parcel geometry while a secondary road connected the two arteries and formed

⁷⁸⁷ Here I am using August Pugin’s terminology to point to the fact that Le Corbusier, through his own education, via the writings of Hermann Muthesius, Raymond Unwin and John Ruskin, among others, shared a similar faith in difficulties generating picturesque beauties. He used different terminology, as well as more corrective measures, his regulating lines, but his own quest for a complexity at the ensemble scale is a variation of these earlier design theories. I have discussed Pugin’s theories in Chapter 3.

⁷⁸⁸ Le Corbusier, “19910 Lotissement De Lege,” (FLC, August 2, 1924). Included in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁷⁸⁹ *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. Confirmed by the dates on the more detailed drawings of the units.

the southern edge of the place, following a straight east west orientation. Like a number of his earlier settlement schemes, the massing here was clearly informed by the position of the moving subject, coming from Lège center, to the west.⁷⁹⁰ One of the lower and wider Type A's was placed as a kind of façade, its length parallel to the street. Receding away from that Type A, directly north, was a series of three Type B's, which while tall enough to be seen behind the first Type A, were diminished in size by perspective. As the viewer moved east along the road and past the southernmost Type A, the two remaining Type A's, parallel to the main road and the east-west axis, but moving to meet the diagonal northeast traffic corridor, were also revealed serially. For a viewer standing on the main road immediately in front of the southernmost Type A, the six units would appear as a single receding relief, with the dynamic synchronic experience relating their shared cellular logic and insinuating a common evolutionary history, in diachronic time. They were houses in series as well as serialized houses.⁷⁹¹ (Fig. 110)

In the initial configuration, Le Corbusier maintained the internal organization of the type variants, calibrating their individuality purely through spatial relations, defined through a series of dimensions, labeled "a" and "b", as rigorously defined as the types themselves. The grouping of the buildings defined an enclosed, but not entirely solid internal space and place generally free of the geometry of the traffic corridors, thereby

⁷⁹⁰ The spatial and temporal sensibility here echoes Behrens, "Einfluss Von Zeit- Und Raumausnutzung Auf Moderne Formentwicklung [Influence of Time and Space-Utilization on Modern Formal Development].", which Stanford Anderson has shown that Le Corbusier possessed, Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*. More so than at Pessac, at least in the completed portions, here, the entry sequence is also clearly influenced by the sequential one-point perspective studies of the Acropolis, and other Hellenic Temple precincts included in Choisy, *Histoire De L'architecture*. and used to illustrate a number of the *L'Esprit Nouveau* articles and *Vers une Architecture*.

⁷⁹¹ Upon visiting the site, I prepared a photographic study of the settlement, which has been recently renovated.

transforming them into promenades.⁷⁹² Each of the six units received their own parcel, indicated by light dashed lines, and the exterior entry stairs were modified to increase privacy, as well as to further lock the serial units into their place. Despite a series of modifications, including the redesign of the basic unit layouts, adjustments to the positions of two of the Type A's, and changes in the internal traffic corridors and planting plans, the architectural grouping of the series, tied to broader site conditions and a particular set of visual planning objectives, proved flexible enough to be maintained even when Poncet's flawed surveying required one of the units to be slightly rotated, in order to remain within the parcel. (Fig. 111) As Unwin pointed out in his manual, the "eye... measures distances and angles ... with difficulty, and very great departures from regularity in certain directions may be made without being noticeable."⁷⁹³ This training in informal adjustments within more formal organizational frames would become even more important at Pessac.

Between August and October, when construction began, both types were changed significantly, while still maintaining the basic logic of the overall ensemble.⁷⁹⁴ (Fig. 112)

Type B lost its elevated ground level entirely but changed less in terms of interior

⁷⁹² The quality of the internal space is very similar to the description of how one defines a modern "place" included in *Town Planning in Practice*. For more on this see Chapter 3.

⁷⁹³ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 137. Unwin also associated this attitude towards planning, that of the formal frame, informally deployed, to the unconscious planning of the Middle Ages, where the "setting out of the buildings was done largely on the ground by the eye, and not transferred from a paper plan by means of an accurate survey with careful alignment." Page 52. Poncet's poor surveying caused the same issue at Lège, albeit with less dire consequences as compared to Pessac. Here, the geometrical irregularity of the units is only visible in an aerial.

⁷⁹⁴ Le Corbusier included construction photos of the project in the first edition of *Oeuvre Complete*, with this important "work ... on the standardization of elements" being removed from later editions. This later omission could have something to do with the work of Poncet, which was "lousy", and carried out by "completely incompetent workers", "stooges" in whose hands "no modern machinery" would ever work. Le Corbusier, *Oeuvre Complete*, 69. Bryan Taylor discussed the construction work at Lège and includes a number of construction photos, in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. A photo of the recently completed settlement, "Maison et Cantine Lège", previously unpublished, is also held by at the FLC, and is visible on their on-line archive.

organization and overall footprint, receiving an agricultural shed appendage.⁷⁹⁵ Type A, a variant of which was being studied simultaneously for Pessac, transformed more significantly, extending in plan to include a covered porch and a balcony on the second level, which could serve as a garage on the ground level.⁷⁹⁶ (Fig. 113) The extension out, as well as the two new voids, changed the reading of the type significantly, moving away from the more cubic expression of the earlier studies of houses in series. This was the first time that the frame was exposed to this degree, still reading as a continuation of the enclosing surface of the architectural interior and collective exterior, and not as distinct frame.⁷⁹⁷ To simplify construction, the more complex system of small mass-produced ceramic hollow splayed tiles specified in the Domino work, which required the use of additional temporary scaffolding and formwork, was replaced by concrete joists, cast on site, next to the structure, using curved metal form work.⁷⁹⁸ Wooden formwork for the sprayed cement membranes, designed by Le Corbusier and fabricated across the street in the lumberyard, was also used throughout the project.⁷⁹⁹ While neither approach was particularly novel,

⁷⁹⁵ Discussed in *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁷⁹⁶ Le Corbusier, "Maison Type A21," (1924). Included and discussed in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁷⁹⁷ Allan Brooks has shown that Le Corbusier learned this approach of skinning a tectonic skeleton from Peter Behrens. At first, he found this approach problematic, as opposed to the more explicit structural rationalism he had been exposed to in Perret's office, but he quickly found it acceptable, for practical as well as aesthetic reasons. Brooks, *Le Corbusier's Formative Years*.

⁷⁹⁸ Le Corbusier had already sought to replace the more labor intensive floor and roof construction of the lost tile method with a similar approach, albeit at a larger component size in his Monol Houses proposal, from 1919, included in Corbusier, "Maisons En Série," 1531-32, 39-40. He used this project to discuss the "crisis of transportation", alluding to the significant cost of transporting heavy materials to the construction site. Here, the light forms could be mass-produced centrally while concrete could be extracted closer to the site, if not on the site. A similar principle informed the Harms and Small system. A map of France, from 1949, showing the specialized shops that would fabricate the infill components for the Unite, the Sectors of concentration of lime and the potential sites of these projects shows essentially the space "attitude in the modern spirit", described in the manuals of scientific management. *The Marseilles Block*, 50.

⁷⁹⁹ A very similar approach was used for a part of the houses built by the Ingersoll Rand Company, in Phillipsburg, New Jersey, in 1917. At the same project, a number of the houses were constructed using a variant of the Harms and Small single pour system. Through this experimental building site, the Ingersoll

the process of experimentally deriving and standardizing a mode of architectural production, one that could work at the building component, unit and settlement scale, certainly was. For Corbusier, “the work at Tonkin, in Lège and in Pessac” was equally relevant in the active process of the “standardization of a constructive element”, with the *typical cell* assisting in the serial process of conception, construction and dwelling.⁸⁰⁰

However, Lège, even more than du Tonkin, was a major disappointment caused by a *crooked contractor* and his *incompetent workers*, leading Le Corbusier to omit the project and discussions of the research conducted from later publications of the *Oeuvre Complete*.

Standardization through production, *Quartiers Modernes Frugès*, Pessac, 1924-1926

The future site of the *Quartiers Modernes Frugès* consisted of a large, nearly flat, parcel, set in a sandy pine barren between an important road leading to Pessac town center, Bordeaux to the north and the railway, although no station, to the south, as well as a secondary east-west road bisecting the property in half. Following Unwin’s principles of town planning in July 1924, Le Corbusier defined a *primary center* at the intersection of the existing east-west road in the center of the site, from which a primary, generally straight traffic corridor moved north and south, and a secondary corridor, parallel to the first, was placed further west, terminating in an expanded cul-de-sac. These corridors created four distinct Sectors within the settlement, later labeled A, B, C and D, moving from the north to the south-west. Sectors C and D, the only ones to be completed, were lower in density,

company concluded that the former approach was significantly cheaper than the latter. A series of articles were published on the project, "Pouring 75 All-Concrete Houses at Phillipsburg, N. J.," *Concrete* (January, 1919), "Ingersoll Type Houses at Phillipsburg and Union," *Concrete* (Jan 1919). and "Ingersoll Type Houses at Phillipsburg and Union," *Concrete* (Aug 1919). At Phillipsburg, the town planner, a landscape architect, used Unwin’s organizational schemes, but bent to *wobbly* lines. A similar construction technique was also explained in *Industrial Houses of Concrete and Stucco: A Survey of the Principal Types and Groups of Permanently Constructed Industrial Houses*.

⁸⁰⁰ Le Corbusier, *Oeuvre Complete*.

consisting primarily of row-houses, duplexes and a few free standing houses in the early scheme, arranged along two streets and forming a large block, in Sector C.⁸⁰¹ The five-meter cells used in the site plan were as much a response to the parcel and traffic planning as they were a general verification that these initial choices would not hinder the further urban and architectural design development of the scheme. Already in the July 24 scheme, to test the viability of the large block in Sector C, Le Corbusier added an overlay of parcel lines; in most of the subsequent studies, the parcels would always be drawn, as they were in Unwin's studies. The western edge of that block was defined by a series of duplexes, very similar in scale and organization to Unwin's organizational schema, the "diagram showing arrangements of groups of houses at right angles to a road to secure a southern aspect".⁸⁰² In the drafted scheme, these marching duplexes follow an even spacing for the first five units, with the potential monotony of this organization broken by a cluster of row houses, parallel to the street, on the eastern edge. In response to the loop road, which connected Sectors C and D, the last four duplexes were shifted forward, so that the corridor was framed between the two of them.

A subsequent sketch overlay on the drafted plan studied what the duplexes would look like if they maintained an even distribution, suggesting that the architect was still not certain how to resolve this particular condition. While the southwest edge of the settlement, designated for a dozen wide-facing row house units, would change the least during the year-long design process, and the northern edge of the settlement would retain

⁸⁰¹ I have summarized this procedure in Chapter 3. The basic lines of the scheme changed little from the first July 24, 1924 scheme during the projection process, despite significant changes in the building groups, a testament to Unwin's principles and Le Corbusier's skill.

⁸⁰² The duplexes of wide facing units, turned perpendicular to the road, were on both sides of the corridor in this case and tied the block to the street. This group is similar to Unwin's organization scheme for optimizing southern exposure.

its basic lines, albeit defined by new types, the most tumultuous part of the settlement design would be the link between the eastern and western blocks of QMF. While this tumult was partially due to the complexity of Le Corbusier's own design, it was mostly due to serious survey errors on the part of Mr. Poncet. However, it was precisely this area of greatest difficulty that would in many ways be the most productive part of the project, both in the generation of *architectural sensations*, intended to be viewed by the residents and visitors, either moving through the settlement or occupying one of its *cubes of air*, and the evolution of types and standardization of methods. Unfortunately though, the compounding of these difficulties with the earlier delays and costs at Lège, would contribute to further economic inefficiency, as well as serious problems with the local bureaucracy, preventing the sale of these units for years.

Between late July and November, as the final documentation for Lège was completed and fabrication and construction had begun, Le Corbusier developed a series of studies at the settlement and unit scale for Pessac. Following the overlay sketch from the July 24th scheme, Le Corbusier moved the roadway west of the series of duplexes running along the main north-west street of Sectors C and D, allowing for an even spacing of the masses and the passage of the corridor between them, as indicated in the undated "Lotissement de Pessac" plan, from this period.⁸⁰³ (Fig. 114) This move led him to shift the

⁸⁰³ Le Corbusier, "19855 "Lotissement De Pessac", (FLC, 1924). Le Corbusier used this plan as the basis of an underlay for a diagram showing the two sectors that had been "completed" by June 1926, C and D, for Giedion's chapter on his work in Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton.*, 88. Giedion compared it to the Lavezzari Hospital, from 1877, purely based on its formal resemblance. This pairing of the two projects followed the general mixture of 18th century universalism and 19th century nationalism. Giedion tried here to reinvent Le Corbusier as the synthesizer of two supposedly French traditions, civil engineering and avant-garde art. The eclectic sources of Le Corbusier's mode of architectural production, some of which Giedion must have known, simply did not fit into this structure. The productions of Le Corbusier are also documented in Anthony Vidler, *Histories of the Immediate Present: Inventing Architectural Modernism* (Cambridge The MIT Press, 2008).

three single family units south, forming a smaller block, as well as to introduce a second set of row houses which would serve as a terminus to the newly placed corridor and further define the enclosedness of this particular street space. In this scheme, undated, but almost certainly drawn before construction in Lège started in October, there are already indications that Le Corbusier planned to use a variant of the new Lège Type A for the clusters of row house units, as well as some free standing units in the large eastern block, visible from the hand drawn “x” annotations indicating the placement of the elevated terraces. The northern edge of the block was then completed with the triplex groupings, also generally based on the Type A, which evolved into the z-shaped types later used to illustrate the principles of standardization, applied to settlement design, in 1929.⁸⁰⁴ As a number of accompanying sketch fragments from this period indicate, the two row house blocks and the z triplex would serve as anchor points around which to lock in the geometry of the series of nine duplexes.⁸⁰⁵ (Fig. 115) This relational approach, primarily developed to ensure that *cubes of air* between the masses were as carefully calibrated as those on the interior, would provide the much needed tolerance the settlement design required to maintain its coherence in light of Poncet’s survey errors.

By November, it had become clear that a significant part of the site where Le Corbusier had planned the road connecting the larger eastern block with the smaller loop road, connecting to the western portion of *QMF*, was in fact outside of the parcel.⁸⁰⁶ (Fig.

⁸⁰⁴ Much of the northern half of the eastern block would be defined at this time, at the massing plan scale, with further variation occurring at the unit scale.

⁸⁰⁵ A very interesting sketch from this period, from late 1924, shows the grouping types that were emerging at Pessac, the duplexes, the z-shaped triplexes and the clusters of row-houses. Here the standard cell, as well as the standard spacing between the cells, was studied, as it had been in the settlement plan of Lège, drawn in August 1924. Le Corbusier, "19913," (FLC, 1924 (Undated)).

⁸⁰⁶ In a drafted study of the “projected” and “real” site dimensions, "19873 Quartier Moderne Frugès: Implantation," (FLC, Undated (1924))., the error’s impact on the current massing scheme was painfully clear

116) This realization would directly impact the organization of the nine duplexes, later called “sky-scrapers”, as visible in a subsequent study, “Frugès Bordeaux”, dated 24 November 1924.⁸⁰⁷ (Fig. 117) Le Corbusier maintained the relationships between the duplexes and the groups of row-houses already set earlier in the fall, shifting the road over one bay of duplexes so that it now fit into the constrained parcel. He also replaced the first duplex on the northern edge with a mirrored single-family variant of one of the z-shaped triplexes, further reinforcing the entry into that street. Since the new space of the street was no longer enclosed by the grouping of row houses, but aligned to one edge, Le Corbusier introduced a new set of masses, set deeper into the eastern block to visually terminate the space of that street.

With a part of the site in a constant state of flux, Le Corbusier turned his focus to this portion of the project, the large eastern block, refining it through the winter of 1924-25, and including it in the subsequent editions of *Toward an Architecture*.⁸⁰⁸ (Fig. 118) He first drew up a series of three detailed site plans of this portion. These large, detailed drawings, allowed for the simultaneous consideration of the building component, architectural and settlement scales as well as the rhythms and motions of construction and occupation. These three drawings would then serve as the basis for a series of studies of the emerging

and would lead the architect to reshuffle his game pieces yet again, further delaying the completion of documentation, permitting and the start of construction.

⁸⁰⁷ "19792 Frugès - Bordeaux," (FLC, November 24, 1924). This sketch overlay was not included a year later, in the November 12, 1925 settlement plan, but it clearly remained in the architect's thoughts, finally reappearing in January 02, 1926. The “skyscrapers” are essentially a double Type A.

⁸⁰⁸ *Vers Une Architecture: Nouv. Éd. Rev. Et Augm.*, 3 ed. (Paris: G. Crès et cie., 1928), 220. The original drawings still used red to indicate the parts of the units that were being revised when the set was made, in February 1925. "19722 a, B, C," (FLC, February 29, 1925). A perspective of part of QMF appeared in the 1924 edition.

fabric, in three dimensions.⁸⁰⁹ One of those drawings, captioned, “1924, Bordeaux-Pessac. Quartiers Modernes Frugès” claimed that the “large settlement” would be “constructed with a cement gun”, which would not happen, and that “a typical element was fixed, in a precise way, and was then multiplied, in a variety of aggregations”, which had already been done in terms of architectural production, and would continue to be done, for the next year.⁸¹⁰ The final claim in the caption, that of the “real industrialization of the construction site”, was true from an organizational point of view. The final abandonment of the cement gun, not only here, but in all of Le Corbusier’s future projects, informed by experimentation, and not simply by custom or theory, would affirm the architect’s later claim of this being “laboratory work”.

Using the laid out frames, at the group and settlement scale, as a base layer, Le Corbusier began the process of the *installation of a specific series of houses into the standard frames*. In a number of the 1922 article’s captions, particularly in the discussions of the Domino projects, Le Corbusier had already theorized this particular approach to architectural production, one that combined the disparate scales of the settlement and the building component, primarily around the space of production. Here, that same indeterminacy of structural frame was also used to plan the organization of the future space of occupation. Simultaneous considerations of the space of production and

⁸⁰⁹ In addition to the perspective, drawn during the fall and added to the 1924 edition of *Toward an Architecture*, there is a second study of the block, undated, but more similar to the drawings dated February 29, 1924. "19864," (FLC, Undated (1924)).

⁸¹⁰ *Vers Une Architecture: Nouv. Éd. Rev. Et Augm.*, 219. The original text reads: Fragment d'un grand lotissement construit au canon à ciment. Un type d'element a ete minutieusement fixé, et il se multiplie avec les combinaisons les plus variées. C'est une veritable industrialization du chantier. In the 2007 translation, the phrase “type d’element” is translated as “typical housing unit”, which is incorrect, since the element discussed here is the organizational cell. It was also not “established”, as it had already been *established*, or chosen, by a number of different individuals, in America and now in France, but was actually “fixed” and set to a dimension of five meters, for this particular site. Cohen 278. This perspective, which was already included in the 1924 edition, is more similar to the organization of the undated site plan, "19855 "Lotissement De Pessac".", than to the November 24 plan, "19792 Frugès - Bordeaux."

occupation, as well as the slight variation of each unit, a potentially time consuming exercise, even on paper, was now possible due to Le Corbusier's significant *rationalization of his own intellectual work*.⁸¹¹ A good example of the ability to install a specific unit into a more generic organizational frame is visible in a series of studies, all of which are dated February 29, 1925.⁸¹² (Fig. 119,120) Starting with the second iteration of the Maison Citrohan, in 1922, Le Corbusier had begun to intertwine standard, ready-made domestic industrial products, with the spaces that accompanied and informed their use, directly following a logic derived from the automobile bodies and machine casings featured in the *L'Esprit Nouveau* articles.⁸¹³ (Fig. 121) In his 1923 study for a "series of houses for artists", the ready-made spiral stair challenged the otherwise cubic volumes, promoting not only a more efficient use of space on the interior, but, by maintaining the autonomy of the found object, an overall architectural rhythm and enclosedness to the communal space defined by the group.⁸¹⁴ At Pessac, the *enclosed* standard domestic products and their related spaces, further emphasized by Frugès in his promotional material for the project, began to be treated like miniature architectonic elements, floating within the interior landscapes of the units. This afforded Le Corbusier significant leeway in efficiently and expressively creating unique spatial configurations, while using a consistent palette of frames, fixed components

⁸¹¹ Here, I am referencing the theories of Wilhelm Lübbert that I discussed in the introduction of this chapter. It is also worth comparing Le Corbusier's work on fifty-four varied units at QMF with that of his first settlement design project, Cretets, exactly a decade earlier, when he had already learned town planning, from Unwin's manual, but had not yet developed a parallel system of architectural production.

⁸¹² This series examined one of the triplex grouping on parcels 56, 57 and 58 at the outer edge of the large eastern block. Parcel 58 is visible at the bottom edge of Corbusier, "19722 a, B, C." Parcel 58 is changed in "19721 501 B Rez De Chaussee," (February 29, 1925), "19722 501," (FLC, February 29, 1925), and "197238 502," (FLC, February 29, 1925), a study of the second level.

⁸¹³ A good example of this interest in machine enclosures are the pair of images on the last page of "Houses in Series" and the first page of "Architecture or Revolution", *Toward an Architecture*, 290-91. The image on the left shows a "low pressure ventilator", whose shape related to the function of the machine and served as a casing for part of the machinery, while the image on the right shows the casing of a "40,000-kilowatt electric turbine" being lowered.

⁸¹⁴ *Ibid.*, 265.

and free floating spaces, many of which now transgressed the boundary between individual unit, private garden and collective space, while still maintaining conventional property boundaries.⁸¹⁵ This complex synchronic planning was again matched by an interesting diachronic game, which mixed both of the types evolved at or standardized through Lège, albeit further modified for their particular configurations at Pessac. Here, the result was two variants of essentially the same two level type, made up of two and a half modules, configured as row-houses and triplexes, and further modified at the shrink wrapped core and garden scale into distinct units.⁸¹⁶

While there is no evidence of the use of projection instruments directly attributable to Taylor, Gilbreth or other members of the Taylor Circle, Le Corbusier's particular treatment of the frame, as an organizational structure during conception and as a constructive scaffold during construction of the unique shrink-wrapping of technological devices, as well as its immediate space of use in a singular space-time bubble, is identical to the route model method advocated for by Frank Gilbreth, in his articles on route modeling.⁸¹⁷ In Gilbreth's case, the overall subject of study was the industrial plant, the factories of that plant, as well as the workstations, equipment and operators within those factories. For Le Corbusier, the subject was the settlement, the groups of units and the particular programmatic Sectors and equipment that supported their use. Common to both

⁸¹⁵ When Poncet was replaced by Summer and his crew, in June 1925, they would literally be installing some of the houses into the reinforced concrete frames constructed by the crooked contractor. Discussed in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*.

⁸¹⁶ In his preface to Boudon's book, Henri Lefebvre wondered whether Le Corbusier would have wanted the subsequent *appropriations* to the houses in series at Pessac. Boudon's own detailed research of these appropriations suggests that the same freedom Le Corbusier had sought for in his intellectual work, allowing him to modify and vary the installed houses in his fixed frames, was precisely the same infrastructure that made the later changes possible. In contrast, the postwar slabs, sitting a few meters south of the QMF, across the railway and constructed following a rationalized constructive system and unit type, simply could not be adapted to this degree and could only be accepted or rejected by their users. Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*, ix-x.

⁸¹⁷ These are discussed in detail in Chapter 2.

were the *free* elements; the equipment represented by the “templates of white cardboard representing the plan area occupied by each tool, or the space devoted to any single purpose” in Gilbreth’s route models were analogous to the industrial products housed in Le Corbusier’s domestic spaces.⁸¹⁸ While it was possible, chronologically speaking, for Le Corbusier to have seen Henri Le Chatelier’s discussion of the route model, published in March 1914, before he began his Domino studies, in 1915, neither the early Domino system nor Le Corbusier’s writings, which begin to mention Taylor and *Taylorisme* in 1918, suggest any prior knowledge, although he was certainly familiar with it by 1922.⁸¹⁹ More significant than Gilbreth’s influence is the fact that both techniques were based on an understanding of the laboratory method and were developed through laboratory work, on a construction site.

It was the same planned indeterminacy between organizational frame and material and programmatic infill, which had allowed for efficiency and expressiveness during the process of conceiving the houses in series, that helped manage the shift in contractors and material systems between March and June of 1925. Still unable to fire Mr. Poncet and unwilling to give up on his dream of sprayed-on-architecture, Le Corbusier moved forward with the fabrication and construction of the frames of the northwestern set of six row-houses and triplex in late March and early April 1925. Construction documents for these types, dated as late as March 26th for the triplex and May 20th for the row house units,

⁸¹⁸ "A New Development in Factory Study: The Use of the Route Model as a Method of Investigation," *Industrial Engineering and the Engineering Digest* XIII, no. 2 (February, 1913).

⁸¹⁹ Mary McLeod reproduced two images from the second edition of Le Chatelier’s book, *Le Taylorisme*, published in 1934. That book reproduced the March 1914 article. Mary McLeod, "'Architecture or Revolution': Taylorism, Technocracy, and Social Change," *Art Journal* 43, no. 2 (1983). In her own article, she includes two images from that book, but does not cite the original date of the Le Chatelier article, nor his sources for those images as being from two 1913 articles, one on route models and the other on micro-motion study, both the work of Frank and Lillian Gilbreth.

provide evidence of the potential practical benefits of Le Corbusier's settlement design system.⁸²⁰ (Fig. 122,123) These drawings also document the introduction of block infill instead of the sprayed cement on wooden forms, for most of the building enclosures, as well as the relationship of mass produced domestic equipment, such as toilets or the windows, set into "cubes of air" between 5 meter clear reinforced concrete frames. They also demonstrate how each unit type, and even each individual unit, was customized to its particular position within the settlement, following a general system, which in turn evolved with each customization, facilitating the process of standardization. These final construction documents for the units set within the large eastern block helped manage the work of Mr. Summer and his more capable team, starting in June 1925, by which time a more rapid rate of two units per week, was achieved. Le Corbusier and his design team spent the winter of 1925/26 finalizing the garden plans of the nearly completed units, further demonstrating the flexibility of the system to adapt and generate particular conditions.⁸²¹ (Fig. 124) During this period, the design team was finally able to resolve the difficulties generated by Poncet's poor survey of the northwest boundary of QMF.

A plan of Sectors C and D, "622 Plan de Situation", dated January 5, 1926, shows the final positions of the wider row-house units in the western-most part of QMF, as well as

⁸²⁰ Drawings of a modified Lège Type B, Le Corbusier, "19724b Frugès Bordeaux Plan No. 67 512," (FLC, March 1924), were also prepared to a significant degree of detail but never built. The triplex units studied in February, were further detailed, through two sheets, "Frugès-Bordeaux 58 Plan 521," (FLC, 26 March 1925). and "Frugès Bordeaux 56-57-58 Plan Des Chaussee 522," (FLC, March 27 1925). in late March. Even more detailed, construction drawings were prepared in May, once it was clear that Poncet would be replaced. A good example of these drawings is a series studying the row-house units, "19743 Plan Rez De Chaussee 61 526," (FLC, 20 May 1925). and "19747a Frugès-Bordeaux Coupe 62 530," (FLC, May 1925). Here, the same basic frame as the one used for triplex units is modified for a different set of conditions. These drawings were prepared in conjunction with even more detailed studies of certain components, particularly the windows as shown in "19741 Frugès-Bordeaux 524 Coupe Vertical/Horizontale Sur Fenstre," (FLC, May 1925).

⁸²¹ Good examples of these drawings are plans of the row-house gardens, "19796 616 Jardins 61-66," (FLC, 17 December 1925), and a detail of the gateways to the gardens, "19795 616 " (FLC, 17 December 1926).

those of the duplex “sky-scraper” units, row-house and triplex units in the eastern block.⁸²² (Fig. 125) The “modifications” to the settlement are still visible in the variants of a number of the units, overlaid on one another in pencil. Here, the modules themselves define the geometry of the settlement, as the traffic corridors, a majority of the parcels and the vegetation have all been omitted from the drawing. Through the resolution of the errors generated by the improper survey, a new type variant would emerge, which shared some similarities with the earlier Ribot House, the Type A, and the “sky-scraper” duplex type, but unlike those two type variants, it was only two levels in height.⁸²³ (Fig. 126) Reflecting the experimental nature of this laboratory work, this unit, a single family free-standing type, was truly generated from the iterative resolution of the settlement plan; it also proved to be the most popular type in a series of surveys run by Mr. Frugès at this time. This unit had evolved out of Le Corbusier’s initial attempt to add another duplex unit, parallel with the existing series of this type, before ultimately rotating the orientation of the unit and reducing the number of cells from three to two and a half, similar to those set in the larger block. Two units of the new type variant were included in the sketch, each set parallel to one another and set deeper within the two blocks in Sectors C and D. A detailed perspective drawing of this study examined how the new type would relate to both the duplex series and wider row-houses in the distance; this drawing also indicates that Le Corbusier

⁸²² "19805 622 Plan De Situation," (FLC, 5 January 1926).

⁸²³ Two of these types were originally planned, "19803 Frugès-Bordeaux N14 626," (FLC, 1926)., and "19815 Frugès-Bordeaux N 39 638," (FLC, 1926)., but only the first was constructed. As the only freestanding house, N14 was not only popular with the general public but also with architects and critics. The N 39 variant was published in Fritz Block, ed. *Probleme Des Bauens [Problems of Building]* (Potsdam: Muller und Kiepenheuer (Bund Deutscher Architekten), 1928)., and N 14 would be the only part of Pessac published in Giedion, *Space, Time and Architecture*, 793. Here it was cropped in a way to obliterate any of the complex RELATION and INTERPENETRATION that Giedion praised so much in 1928 and in which his whole concept of space-time architecture was based. Here the cropping did serve to suggest a relationship with the earlier work of Tony Garnier, shown opposite the photo.

considered eliminating the pesky roadway altogether, attempting instead a pedestrian path with cul-de-sac access to the back of western most portion of QMF, in lieu of the loop road initially planned and eventually executed, albeit in modified form.⁸²⁴ (Fig. 127) A massing plan dated January 27nd included the final *fixing* of the roadways initially established tentatively, in July 1924.⁸²⁵ (Fig. 128) The lines of traffic were set after all fifty three units, the real generators of the scheme's streets and places, were definitively located.⁸²⁶ This scheme included four units designed according to the new single-family freestanding type. While only one of the units would ever be constructed, it would define much of the formal language and socio-spatial organization of the fully *free-planned* villas of the late twenties.

Less than three months before the planned opening of the *quartiers*, a plan detailing the electrical conduits of Sectors C and D was completed and submitted for final approval on March 3, 1926.⁸²⁷ Following Unwin's planning principles, the seemingly freestanding architectural groupings shared the benefits of common infrastructural *roots*. With these

⁸²⁴ The perspective, Le Corbusier, "19859 (Untitled)," (FLC, 1926 (undated)), shows a variant of the January 5, 1926 plan that does not appear in any of the site plans, both in terms of the exact placement of the units, the vegetation or the traffic corridors. While differing in terms of tectonic expression, this perspective serves essentially the same purpose, in terms of architectural production, as a number of the perspectives shown in *Town Planning in Practice*. In character it is closest to Unwin and Parker's own more reduced studies, such as Illus. 245 – Sketch, showing the effect of a junction planned, as did Illus. 244. Both use the basic placement of their respective cells in space and time, as well as the use of building components, whether they are roofs and chimneys, or roof gardens and exterior stairs, to generate an ensemble as precise as a work of architecture but with the softer edges of a Ruskinian "nest of buildings".

⁸²⁵ "19810 Frugès-Bordeaux 630," (27 January 1926). The seven horizontally oriented row house units, defined the western edge of Frugès-Bordeaux; these units, a variant of the Monol House studies, in terms of construction, and similar in plan to many of the other units at Pessac, experienced the least evolution and adaptation, or trial and error, during the process. There were also eight duplex "skyscraper" units, totaling sixteen units in all, marching along the north-south street that ran through Sectors, C and D. The row-house type, closest in organization to the modified Lège Type A, existed in three variants, the two triplex units, totaling six units, the three row-house clusters, two with six and one with five units, totaling 17 units, as well as three freestanding variants, totaling 26 units in all. Lastly, there were four of the new freestanding units, only one of which, N 14, would be built.

⁸²⁶ The same order of the units being defined before that of the lines of traffic or the landscape was also followed at Lège the previous summer, as shown in a set of two studies, mislabeled as "Pessac Jardin". "19942," (FLC, 22 May 1925). and "19943 (Mislabeled 'Pessac Jardin')," (FLC, 22 May 1925). (Fig. 129)

⁸²⁷ "19818 641 Double Canalisation Électrique," (3 March 1926).

roots set, Le Corbusier turned to *installing* houses and gardens in series within the north-south street of “skyscrapers”, as shown in a series of studies from April 1926.⁸²⁸ (Fig. 130) The freedom between frame and infill allowed for last minute changes to each unit. These drawings show how this flexibility allowed for the deft resolution of car access (something that would be raised to a more artistic level at the Villa Savoye), pedestrian entry, allotment garden definition on the parcel, and comparable modifications in the placement and articulation of the *shrink-wrapped* domestic equipment, ranging from toilets to automobiles, within the skyscraper units themselves. Even though the basic frames along the troublesome street connecting Sectors C and D were now defined, Le Corbusier would continue to study at least three different alternatives as to how to define the space between the skyscraper units and the single family unit set behind them.

The paint schemes for the entire settlement were also defined at this time, adding another standard element to the palette of variable features of the houses in series, which simultaneously distinguished and unified the individual units. The decisions around the final polychromatic scheme were made using a plan-oblique drawing of Sectors C and D as an underlay.⁸²⁹ (Fig. 131) These studies examined the potential *picturesque beauties*, which

⁸²⁸ "19827 670 Clotures Et Jardins," (FLC, April 1926), "19821 Jardins Et Clotures 671," (FLC, April 1926). and "19829 673, 674," (FLC, April 1926). The final configuration of the southern edge of larger block, "19830 Jardins Et Clotures 678," (FLC, April 1926), was also completed at this time.

⁸²⁹ "19838 Quartiers Modernes Frugès Quarier Du Moteil Secteurs C D 690," (FLC, Undated (1926)). Published in Le Corbusier, *Oeuvre Complete*, 79. The polychromic studies, generated from this plan oblique drawing are published in Taylor, *Le Corbusier at Pessac: The Search for Systems and Standards in the Design of Low Cost Housing*. The process of selecting the colors, as well as the reasoning for the scheme, is explained in an interview with Frugès included in Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*. The process and even the specific color palette used at Pessac is very similar to the drawing exercises included in Ruskin, *The Elements of Drawing: In Three Letters to Beginners*. Here, Ruskin would redraw John Turner's landscape drawings of the built environment, translating the more complex fields of color into zones of hatches and other patterns. He would then further rationalize the objects of the composition into component parts, often relying on techniques developed by Albrecht Dürer, before explaining to his young pupils how these techniques could simulate the landscapes that they themselves observed. These more geometric landscapes could then be translated again into fields of color. For a

had emerged from the *difficulties* of raising an elevation rationally from a flawed survey, or as Le Corbusier would put it in 1926, studying the “unexpected aesthetic” that had “emerged” during the process, “conditioned by the imperatives of construction”, as well as the “sensual effects of architectonic volumes”.⁸³⁰ According to Frugès, these polychromic studies were intended to further correct the repetitive nature of some of the groupings, at the settlement scale, just as Le Corbusier’s regulating lines technique corrected the relationships of standard windows at the group scale, starting with the Villas Roche-Jeanerette (1922-24).⁸³¹

When a substantial crowd, consisting of members of the general public and more esteemed representatives of the entire region of Aquitaine, as well as Mr. Monzie, France’s Minister of Public Works, arrived on June 13th, 1925, for the *QMF*’s soft opening, forty-nine of the fifty-three planned units were mostly completed, with only a few entirely equipped, and little of the lush landscape of this *cite jardin* even planted. Frugès would later sum up the atmosphere by explaining that 1% of the visitors seemed truly “enthusiastic”, 2% “sympathetic”, 2% “hesitant”, 40% “worried and stupefied” and 55% “convinced that (he) had gone mad”, many of that majority referring to the project as *rigolatorium*, or a kind of circus.⁸³² In his speech that day, Minister Monzie was impressed that the “Bordeaux region”, viewed as conservative and provincial as compared to Paris, was the site of such a

discussion of Le Corbusier’s knowledge of Ruskin, see Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier*.

⁸³⁰ Le Corbusier’s speech on June 13, 1926. Reproduced in Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*.

⁸³¹ Interview with Frugès, *ibid*. Le Corbusier discussed his use of regulating lines as a corrective measure, not as the primary tool of spatial or tectonic organization in “Regulating Lines”, Corbusier, *Toward an Architecture*, 131-44. As I have shown earlier in the chapter, in 1950, he would be even more explicit about his design sequence, one that started with the selection of a type, followed by standardization, followed by the fixing of a dimension, with the study of proportion coming at the end of the process. Here polychromy appears in the same phase of the design work.

⁸³² Interview with Frugès, Boudon, *Pessac De Le Corbusier: 1927-1967 - Etude Socio-Architecturale*, 12.

laboratory, assuming that since the project was constructed it would soon be inhabited.⁸³³ In his own speech, Le Corbusier delivered a variant of the text he would frequently reproduce, claiming that it was Frugès who had stated that “Pessac must be a laboratory”. He acknowledged the problems faced with Mr. Poncet, adding that everything the visitors saw had been built since July 1925. He praised the work of Mr. Vrinat, though not by name, explaining that while construction had been delayed, limiting the benefits of his industrialized system of housing delivery, fabrication, following the same system, had been carried out simultaneously, due to the consistent use of a fixed module at the settlement scale. This was only the “first step of this industrial program”, one that would continue to be refined through the construction of the “last two sectors (A and B)”, where the “lessons learned ... from our experiences to date” would finally lead to “complete industrialization and complete Taylorization of the building site, thus ensuring quality and economy”⁸³⁴; thus far, the laboratory had only yielded innovation. At the closing, Le Corbusier repeated praise for Frugès’ “bold initiative, his perseverance and indomitable courage... during the most difficult moments” of this “unusual experiment”, and general largess for establishing a laboratory to generate standards and to “offer them (freely) to those who stand in need of low-cost housing but who are unable to organize a research establishment.”⁸³⁵ In other words, thus far Frugès had paid for the experimental derivation and standardization of industrialized housing delivery methods, and only now would he and Le Corbusier be able

⁸³³ Excerpt from a June 13, 1926 speech. Ibid.

⁸³⁴ June 13, 1926 speech. Translated in Boudon, *Lived-in Architecture: Le Corbusier's Pessac Revisited*. Sectors A and B would be studied for the next three years. Here, Le Corbusier hoped to increase the degree of onsite fabrication work, as indicated by his first true construction plant plan, Le Corbusier, "19835 758 Amenagement Provisoire De La Place " (FLC, 11 September 1926). That drawing was made in conjunction with a revision of the place that would serve to link Sectors C and D with that of Sectors A and B, as indicated in , ed. 19832 730 Fruges Bordeaux Secteurs AB (FLC, 20 September 1926). (Fig. 132)

⁸³⁵ Ibid.

to apply these still tentative standards efficiently and economically, an ambition they hoped would be realized with the revenue from the sale of the forty-nine completed units.

Due to a number of problems with the physical state of the settlement, which would be repaired, as well as a number of problems with the applications for building permits, based on incorrect surveys by Mr. Poncet and essentially rendering the project an illegal construction, the connection of municipal utilities to the units, and therefore their sale, was delayed until 1929, despite interventions by Ministers Monzie and Loucher. The initial flaws generated by the rushed experimental construction work would be exaggerated by three years of abandonment, neglect and vandalism. By that time, the Frugès family was nearly bankrupted by the endeavor, with Henri Frugès compelled by the episode to move to French Algeria and Le Corbusier encouraged to eschew future partnerships with enlightened entrepreneurs in the hopes of receiving support from political parties.

Conclusion

A close examination of Le Corbusier's laboratory work in Bordeaux suggests his biggest mistake was not simply his faith in technology or his own evolving architectural production system, but rather his naiveté regarding the application of scientific management's laboratory method within a highly bureaucratized context. The architect knew, but seems to have simply taken for granted, the fact that Raymond Unwin had to lobby for the passage of an actual law, the Hampstead Act of 1906.⁸³⁶ It was not until the passage of this law that he established the *laboratory* through which he would demonstrate what would be possible if English building code were to be liberalized, giving more agency to local councils and individual town planners. If that act had not been passed, the

⁸³⁶ For more on this, see Chapter 3.

Hampstead Garden Suburb would have experienced the same problems, regardless of the patronage of philanthropist Henrietta Barnett, or the political support of MP John Burns. The failure of Le Corbusier's laboratory of industrialization, standardization and Taylorization was related to the lack of bureaucratization of Poncet's construction firm and the over-bureaucratization of French building regulations.⁸³⁷

Despite this lack of legislative autonomy, Le Corbusier's laboratory work was as successful for him, and his discipline, as Taylor and Gantt's experimentation and standardization was at Bethlehem Steel. Much like Taylor's high-speed steel tools or Gantt's Gantt chart, this work generated influential standard methods, instruments and parameters, without ever fully achieving an economical equilibrium; at least Le Corbusier, unlike Taylor, was not fired. In 1922, Le Corbusier had already conceptually separated structure from enclosure at the architectural scale and unit from ensemble at the settlement scale. However, it was not until 1925 that he would apply this same concept to the planning of the *workstations* of his *tools for living*, as is visible in the variants of the Maison Citrohan designed before and after the laboratory work at Bordeaux.⁸³⁸ A similar evolution in Le Corbusier's mode of architectural production is explained in a spread of the *Oeuvre Complete*, pairing a "regulating lines study of the facades" of the Villas Roche-Jeanerette on the left page with a "study for standardizing a settlement", Pessac, on the right. Both projects had started in a similar fashion, namely as Unwinian organizational

⁸³⁷ Henry Harms complained that the "French ... suffer under an amazing mass of 'red-tape'", but he also stated that they had "been building industrial houses in Holland, Belgium and France, because America was not yet ready." The state of crisis, generated by wartime conditions was probably the single most decisive factor in Harms and Small's ability to experiment during this period. Henry J Harms, "What French Industrial Dwellings Cost," *Concrete* 12, no. 3 (March, 1918): 177.

⁸³⁸ See Fig. 120.

schemes using cells or frames informed by the earlier Domino studies.⁸³⁹ In the case of the Villas Roche-Jeanerette, the frame or cell had been *established*; it had served as a tentative organizational standard. In the case of Pessac, the cell or frame had not only been established, but it had been fixed, *experimentally*, through the construction of the Maison du Tonkin, to a five-meter clear module, with that module then serving to help plan Pessac. The windows for the Villas-Roche Jeanerette were *established* and *fixed*, analytically and intuitively more than experimentally, into a system of modular units that could then be grouped into various ensembles, which responded to internal logics and ordered the spatial and temporal experience of the exterior space, as well as the exterior-interior architectural promenade. In addition to being dimensionally fixed, the individual modules and their interrelationships had been “corrected” through the application of regulating lines. At Pessac, the fixed module provided a similar ordering principle to the individual units, the groups and the spaces between the groups, whose dimensions and proportions had been similarly studied dimensionally and proportionally, after the cells were placed and loosely grouped. The fixed frame dimensions also afforded a more controlled frame for the experimental derivation of a new method of routing, *free-planning*. Le Corbusier, speaking in the third person, proudly related the experience of managing his own conception process:

The standardized plan allowed Le Corbusier to fix a particular element as the basis for Pessac. These rational building blocks do not destroy individual initiative. They allow one to play according to ones’ own taste.⁸⁴⁰

⁸³⁹ The project began as one of three villa settlements advertised in *L’Esprit Nouveau* Vol. 18 (1923). These drawings are from a single sheet, Le Corbusier, “9205,” (FLC, Undated (1923)). There are numerous studies of the grouping of the units, at the scale of the cul-de-sac street, including “15102.,” “15108,” (FLC), and “15199,” (FLC). The spread is included in Fig. 82.

⁸⁴⁰ Giedion argued that “(i)n his theory Le Corbusier is often less daring than in his design”, because of his “overlay (of regulating lines) on to the façade” of the Villas Roche-Jeanerette. “This is permissible for a uniformly elaborated, anthropomorphic architecture”, argued Giedion, “(b)ut in the case of Corbusier it is

It was actually the *standardization of planning*, what Wilhelm Lübbert, the head of the experimental settlements program in Germany, would call the *rationalization of intellectual work*, that had been the primary *architectural research* in Bordeaux. Whereas the initial edition of the Oeuvre Complete, included a more complete narrative of the *series of important experiments* at Bordeaux, including the Maison du Tonkin, where the frame module was fixed, and Lège, Le Corbusier's first group of houses in series, later editions omitted those projects and as such, the actual process of experimentation and standardization, following the laboratory method, was replaced with a much more rationalistic account of the project. In 1950, Le Corbusier partly corrected this omission, through his explanation of his "method" of "laboratory work", one that began with identifying an already established standard, or type, and engaging in the process of standardization, through a laboratory, fixing a measure or dimension for a given project, and finally applying proportion to correct it, visually. But by then, a very different understanding of his work had been defined, partially by him and partially by his advocates, such as Siegfried Giedion.

absurd", because "(t)he proportions that will result from standardization are no longer restricted by the old formula, but apart from this, these proportional formulae are invalid today because a BUILDING is no longer a closed form like a Renaissance palace but demands CONNECTION TO THINGS NEXT TO IT." Giedion, *Bauen in Frankenreich, Eisen, Eisenbeton.*, 92. In reality, it was Giedion's understanding of form that lacked "daring"; he believed that standardization, whatever that was, had been directly generated from the logic of reinforced concrete construction and that it generated form in turn, or at least this is what he was arguing. In his own theoretical texts, before and after Pessac, Le Corbusier clearly distinguished between the things that he directly controlled and the things he had appropriated from other disciplines. He was also clear about the applied nature of his regulating lines. He had learned these theories from Peter Behrens, Hermann Muthesius, and other architects, by 1910, and they were further enforced by the literature of scientific management. When Alfred Barr claimed that "Le Corbusier is even more concerned with style than with convenient planning or plumbing", in 1932, he is in fact debating with Giedion more than Le Corbusier. Henry-Russell Hitchcock and Philip Johnson, *The International Style* (New York: W.W. Norton, 1996 (1932)), 30. The same thing can be said for Colin Rowe's excavation of the supposedly suppressed Academicist strains of Le Corbusier's work, discussed in Rowe, "The Mathematics of the Ideal Villa." A more nuanced theorization of Le Corbusier's relationship to Academic composition has been put forth by Stanford Anderson, through his idea of *critical conventionalism*, in Anderson, "Critical Conventionalism in Architecture."

During the interwar period he would never again have the opportunity to experiment at the same scale of social space. When offered the opportunity for a second great “laboratory” at Marseilles in 1945, finally supported both financially and legislatively by the State, through the patronage of the French Ministry of Reconstruction, Le Corbusier was less prepared to iterate, as he had in 1925, than to demonstrate the ideas he had developed on paper or had generated through his earlier laboratory work at Pessac.⁸⁴¹ The Unite was more similar, in ontological terms, to Behrens’ demonstrations of the grouped building method than it was to the laboratory work in Bordeaux. The equivalent of the obsession with the cement gun at the Unite, the fully prefabricated unit, which would be inserted into a site cast frame, persisted well after the belief in the conventionality of this procedure proved premature, or more precisely out of date. The fully prefabricated units being constructed in the United Kingdom and France, some designed by Jean Prouve, made economical sense for the first few years of reconstruction but were discontinued after only a few years, and with them an industrial ecology that might have supported the concept of the Unite.⁸⁴² Nevertheless, Le Corbusier’s laboratory work would influence the work of his peers in Germany, particularly that of Ernst May, whose own “experimental settlement” was established a few months before Pessac’s soft opening. Here, better access to the instruments of experimentation and standardization, already adapted to construction by Gilbreth, and to settlement design by Martin Wagner, Le Corbusier’s translation of the laboratory method into architectural production, and May’s training in settlement building,

⁸⁴¹ Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier*.

⁸⁴² Robert T. McCutcheon, "Science, Technology and the State in the Provision of Low-Income Accommodation: The Case of Industrialized House-Building, 1955-77," *Social Studies of Science* 22, no. 2, Symposium on 'Failed Innovations' (1992). Brenda Vale, *Prefabs: A History of the Uk Temporary Housing Programme* (London: Chapman & Hall, 1995). Peter Sulzer, *Jean Prouve: Complete Works* (Basel: Birkhauser, 2000).

from Unwin himself, allowed for an even more thorough application of scientific management to architectural production. As I will show in the next chapter, while Walter Gropius and Ernst May began their own “experimental settlements”, around the time of the QMF’s soft opening, without the clarification of the relationship between *Scientific and the State*, through a process that had started in 1917, with the launch of NADI, and had expanded outside of the factory by 1926, these laboratories would have suffered the same problems as the QMF.

Chapter 5. The 'Experimental Settlement': Walter Gropius's Dessau-Törten and Ernst May's Praunheim Settlements, 1926-1930

In a lecture given on January 12, 1929, Ernst May, the only German architect to have been trained by both Theodore Fischer and Raymond Unwin, explained how four years of "housing policy in Frankfurt" had been managed. As a fluent English speaker, the architect prepared his own translation of the German speech, in which he chose to translate three different words, *durchgebildet*, usually translated as "formed", *entworfen*, usually translated as "designed", and *ausgearbeitet*, usually translated as "prepared", with a single consistent term, "evolved".⁸⁴³ Through a series of settlements, he and his team had "evolved a total of eighteen types for the requirements of the population" of Frankfurt.⁸⁴⁴ The "smallest dwelling types", *Kleinstwohnungen*, later referred to as *existence minimum*, had been "evolved with the desire to enable the poorest class of the population to secure a habitat", as well as to provide a built-in potential for expansion in better times when the housing shortage was over.⁸⁴⁵ The team had also "evolved *Normenblätter* (instruction cards) for use not only in municipal building but in all building of dwellings" within the municipality.⁸⁴⁶

May's evolutionary and experimental work was part of the *Versuchssiedlung*, or "experimental settlement" program, supported by the "The National Research Association for the Systematization of Building and Dwelling Methods" (RFG).⁸⁴⁷ Like the DIN-Norm

⁸⁴³ Ernst May, "Housing Policy of Frankfurt," *Das Neue Frankfurt* Special Edition (January 12, 1929): 27-31. The text was published in German, French and English.

⁸⁴⁴ *Ibid.*, 27.

⁸⁴⁵ *Ibid.*, 31. "Existence minimum" was the topic of the second CIAM congress, held in Frankfurt in October 1929. For more on this event see Eric Mumford, *The Ciam Discourse on Urbanism, 1928-1960* (Cambridge: The MIT Press, 2002).

⁸⁴⁶ May, "Housing Policy of Frankfurt," 31.

⁸⁴⁷ *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* e. v. While the RFG is often cited in discussions of modern architecture in interwar Germany, there is no book length study on this important association. In a number of cases, the interest in *Wohnungswesen* is even dropped from the title,

program, the “experimental settlement” program provided political, economic and technical support for the explicit goal of experimentally deriving and standardizing “types and norms”, through settlement-building, to be offered as voluntary standards for use by German professionals or formatted as the basis for new obligatory building codes.

The RFG had been formed in January 1927 as a direct descendent of the “National Committee on Types”⁸⁴⁸; both were composed of highly influential committee members representing a spectrum of disciplinary expertise. The RFG’s support would prove crucial in enabling May, as well as Walter Gropius⁸⁴⁹, the manager of another experimental settlement, to experiment and standardize industrialized housing delivery systems. However, much like the Hampstead Act of 1906, which had allowed Raymond Unwin comparable autonomy from current regulations, the “experimental program” had been developed through the lobbying efforts of May, Gropius, Marie-Elisabeth Lüders⁸⁵⁰ and Wilhelm Lübbert, a Berlin-based architect and head of the experimental housing program, specifically to assist experimentation that had already been planned, staged and initiated before the “experimental program” was even proposed, in October 1926. In other words, the framework resolving the relationship of the individual space of experimentation and

for example in Manfredo Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's* (Cambridge: The MIT Press, September 1987), 218., reflecting the perception that the RFG was primarily focused on issues of construction. The most thorough discussion to date is included in a chapter of Andreas Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm* (Dresden: Thelem Universitätsverlag, 2010), 230-38.

⁸⁴⁸ The *Reichstypenausschuss*, or “National Committee on Types”, was formed in June 1926. Discussed in *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*, 230-35.

⁸⁴⁹ Gropius was director of the *Staatliches Bauhaus* in Dessau, where he hoped to establish an “experimental settlement” that would also serve as the pedagogical core of a new architectural education.

⁸⁵⁰ Marie-Elisabeth Lüders (1878-1966), was a Reichstag representative of the *Deutsche Demokratische Partei*, (DDP) or German Democratic Party, founded by Walther Rathenau and Friedrich Naumann in November 1918. Lüders took Naumann’s seat when the Party founder and Werkbund member died, in 1919. Peter Behrens had hoped to gain support from the DDP for his “grouped building method”, citing Naumann in his 1918 manual and asking another part of his circle, and future member of the DDP, Bernhard Dernburg, to write a preface. Ludwig Landmann, the DDP mayor of Frankfurt, would support Ernst May’s experimental work in that city.

standardization to the municipal, state and national context, was itself designed. May and Gropius' settlements, Praunheim and Törten, were not the only ones to receive support from the experimental settlements program, with two other settlements, the *Weißenhofsiedlung* in Stuttgart and the *Postversuchssiedlung* in Munich, also participating; the experimental settlements program was only one of a number of initiatives coordinated by the RFG.⁸⁵¹ Nevertheless, I will demonstrate that only May and Gropius' work constituted the application of the laboratory method, both to architectural production, as well as to settlement-building itself.

Before discussing Gropius and May's experimental settlements, I will briefly discuss the discourse on the relationship of scientific management, particularly the laboratory method, and the State, demonstrating that Taylor and other members of the Taylor Circle only briefly considered this issue, often pointing to developments in Germany as a model for standardization, at a national scale, in America. I will then discuss the more direct roots of the "experimental settlement", in the writings of Ebenezer Howard, Hermann Muthesius, Martin Wagner and Wilhelm Lübbert. Finally I will provide a brief history of the RFG and an example of one of the other programs supported by the association, before discussing Gropius and May's laboratory work.

Scientific Management and the State, Gilbreth, Gantt and Germany

Scientific management, along with modern industrial management in general, was initially developed to bring organization, even bureaucratization, to the machine shop of

⁸⁵¹ All four of these settlements received funding from, and were assessed by, the RFG, between 1928 and 1929. The *Weißenhofsiedlung* and the *Postversuchssiedlung* were both added after Törten and Praunheim. The *Weißenhofsiedlung* was not initially referred to as an "experimental settlement", and the assessment focused on four of the multi-unit types, not the settlement as a whole. The *Postversuchssiedlung* was deeply informed by Törten and Praunheim, starting more than a year after those settlements. I will discuss both briefly later in this chapter.

later competitive capitalism, in America, between 1880 and 1917.⁸⁵² Before 1917, when that organizational system began to influence the public sector in America, it had already crossed the Atlantic. While it was French engineers who showed the earliest interest in this approach, with Henri Le Châtelier influencing the reception of *le system Taylor*, not only in his own country but throughout the Continent, Germany would serve as the site for some of the earliest applications of these principles to the public sector.⁸⁵³ The most cited example of this process, which occurred on multiple fronts, was the founding of the *Kriegsrohstoffabteilung* (KRA), or “war-time raw materials administration”, in 1914, by Walther Rathenau, the young owner and director of the AEG, and Wichard von Moellendorff, a mechanical engineer and member of the AEG executive board.⁸⁵⁴ While this event marked the more thorough incorporation of the principles of systematic and scientific management into the German bureaucracy, a process that some scholars have argued even had a liberalizing effect on an organization that had been rooted in Prussian militarism, it was another event, in 1917, which would define the relationship of individual

⁸⁵² While Frederick Taylor did claim that scientific management could be applied to public administration, he did not consider this in any detail. Taylor’s relationship to the public sector as a whole was generally oppositional, with the father of scientific management suspicious of external interference in the space of industrial production by anyone other than industrial engineers. As Alfred Chandler argued in 1977, the *visible hand* of management had in fact developed as a response to the chaotic *invisible hand* of the market, reorganizing the space of the factory before informing the particular, and relatively late, formation of a modern bureaucracy in America, during the first decades of the twentieth century, accelerated by the First World War. Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge: Harvard University Press, 1977). Chandler’s argument serves as the foundation of James Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, MA: The Harvard University Press, 1986). For a history of the appearance of scientific management in public administration in America, see Hindy Lauer Schachter, *Frederick Taylor and the Public Administration Community: A Reevaluation* (State University Press of New York, 1989).

⁸⁵³ David Nelson, "Introduction," in *A Mental Revolution: Scientific Management since Taylor* ed. David Nelson (Columbus: Ohio State University Press, 1992).

⁸⁵⁴ Ibid. Judith Merkle, *Management and Ideology: The Legacy of the International Scientific Management* (University of California Press, 1980). Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (Cambridge, MA: The MIT Press, 1997).

industries to the State. That event was the establishment of the *Normenausschuß der deutschen Industrie* (NADI), or the “Standardization Committee of Germany Industry”.⁸⁵⁵

As I have already discussed in Chapter 1, NADI was not a central governmental agency that would develop industrial standards for German industry but instead functioned as a non-governmental agency, which formed committees of professionals to collect tentative standards from individual industries. From this process, DI-Norms, or what Frank Gilbreth called superstandards, or *Deutsche Industrienorm*, were issued for voluntary use by those same industries.⁸⁵⁶ As Hermann Muthesius observed, this process of standardization, or what he would have called typification or type-building, maintained the contingency of types while at the same time encouraging their further evolution.⁸⁵⁷ While the RFG grew directly out of NADI, renamed *Deutscher Normenausschuß* (DNA), or “German Standardization Committee”, in 1926, it was only the experimental program, and particularly the work of May and Gropius, which demonstrated a similar modification of the laboratory method. For both NADI and the RFG, this method retained the individual spaces of production as the primary sites of experimentation and tentative standardization, while at the same time connecting these individual sites with the production of tentative national, and even international standards.

The DI-Norm program fulfilled one of the two roles that Frank and Lillian Gilbreth advocated that the State play in relation to the scientific management of industry, in the expanded German language edition of their *Primer of Scientific Management* (1914), the *Das ABC der wissenschaftlichen Betriebsführung* (1917), namely that it coordinate, but not

⁸⁵⁵ See Chapter 1

⁸⁵⁶ See Chapter 1.

⁸⁵⁷ See Chapter 1.

initiate the production of standards.⁸⁵⁸ The other role advocated by the Gilbreths, in 1917, was that the State educate professionals in the principles of scientific management, which was already occurring in Germany, as early as 1912; this would also be part of Walter Gropius' motivation to establish his "experimental settlement" in 1926, as a kind of open air classroom for the Bauhaus in Dessau. While there is little likelihood that either NADI or the Gilbreths were aware of this synchronous occurrence in 1917, both reflected common ideas and experiences. By 1922, Gilbreth, along with other American engineers, would use the NADI program as supporting evidence for a similar standardization program in the United States.⁸⁵⁹ Henry Gantt would also consider the issue of Scientific Management and the State, in his last publication, *Organizing For Work*, in 1919. His call for a "public service corporation" would in many ways be fulfilled by the work of the RFG.⁸⁶⁰

⁸⁵⁸ The title of the passage, "Scientific Management and the State", not included in the previous editions of the *Primer*, was similar, albeit reversed, to a chapter in Sidney Webb and Arnold James' book, *The State and "Scientific Management"* in *Great Britain After the War* (1916). These two Fabian Socialists and Labour Party members, argued that regardless of what one thought of the "mechanism" of scientific management, its application was inevitable, since "what Germany does to-day in trade matters, England is apt to do to-morrow." The real issue in introducing this "mechanism" was considering "what regulations can be framed by (ones) Union, what laws can be passed by Parliament, in order that wherever Scientific Management is introduced, it shall be used only in such ways as will benefit the community, and not in such ways as will degrade the condition of the manual worker." Sidney Webb and Arnold James Freeman, *Great Britain after the War* (London: George Allen and Unwin, September, 1916), 63.

⁸⁵⁹ In spite of ideological differences, these programs had more in common with Aleksei Gastev's Central Institute of Labor in Moscow, where Gilbreth's motion study instruments and methods were developed well beyond anything he had been able to do in the industries whose production spaces he had coopted for his own "laboratory work". Despite having had a more direct influence on Gastev's laboratory, Gilbreth deeply admired Germany's political economy and the NADI program. For a good overview of Gastev's work see Kendall E. Bailes, "Alexei Gastev and the Soviet Controversy over Taylorism, 1918-24," *Soviet Studies* XXIX, no. 3 (1977). For a collection of Gastev's most important articles from the twenties see Aleksei Gastev, *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda* (Moscow: TsIT, 1966).

⁸⁶⁰ In 1919, Henry Gantt introduced the notion of a "public service corporation", as a response to what he saw as the "menace to industrial (as well as) international peace" present by "autocratic power", embodied in America by the *Banker* and in the newly formed Soviet Union by the *Bolshevist*. Both were "extreme radicals" who were taking advantage of the "economic catastrophe" brought on by a combination of militarism, imperialism, as well as the laissez-faire system of industrial capitalism of the late 19th century. Gantt called for a "parting of the ways" in America, hoping that "those in control of industry (would) recognize the seriousness of the situation" facing an increasingly globalized world, and to "recognize the responsibility of the industrial and business system to render such service as the community needs." Using his own war experiences as a consultant for the Emergency Fleet Corporation, Gantt theorized what a public service

The Settlement as 'Municipal' and 'National Experiment', Ebenezer Howard and Raymond Unwin

The broader ideas of the RFG, as a non-governmental association collecting, synthesizing and issuing national standards in order to systematize building and dwelling can be attributed directly to NADI, and more generally to the provisional theories regarding the role of the State in standardization. Alternatively, the notion of the experimental settlement as architecture's equivalent to that of the industrial plant can be traced to more specifically disciplinary sources, namely the theories of the garden city movement. This is particularly true of Ebenezer Howard's notion of the garden city as a site of "municipal experimentation", where decisions regarding the spatial and economical planning of a community would be decided through a process of *trial and error*, as well as the site of "national experiments", with individual garden cities offering alternatives for national legislation.⁸⁶¹ He described the garden city movement as an "experiment", whose "parts are ready to be had and have but to be fitted together", as opposed to "communistic experiments", generally created out of "various (raw *ores*) which have first to be gathered together and then cast into various shapes."⁸⁶² Howard acknowledged that while the "pathway of experiment towards a better state of society is strewn with failures", this was

corporation might function like. Henry L. Gantt, *Organizing for Work* (New York: Harcourt, Brace and Howe, 1919).

⁸⁶¹ In his discussion, Howard would distinguish the Garden City movement both from specific attempts at establishing cooperative communities, as well as from the general ideologies of socialism and communism. To Howard, many of these endeavors and ideologies lacked balance in their considerations between the community and individual, as well as the desire to start over and to deduce an ideal social organization. Ebenezer Howard, *Garden Cities of to-Morrow* (London: Swan Sonnenschein & Co., 1902), 96-98. For a general discussion of Howard's ideas, see Robert Fishman, *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright and Le Corbusier* (Cambridge: MIT Press, 1982). For an analysis of the relationship between Howard and Unwin, see Walter Creese, *The Search for Environment: The Garden City, before and After* (Baltimore: The John Hopkins University Press, 1992 (1966)).

⁸⁶² Howard, *Garden Cities of to-Morrow*, 100.

essential to true experimentation, with “(s)uccess (being) built of failure”.⁸⁶³ He even provided two linked scales of experimentation, that of the settlement and that of the nation:

... what the whole experiment is to the nation, so may what we term "pro-municipal" undertakings be to the community of Garden City or to society generally. Just as the larger experiment is designed to lead the nation into a juster and better system of land tenure and a better and more common-sense view of how towns should be built, so are the various pro-municipal undertakings of Garden City devised by those who are prepared to lead the way in enterprises designed to further the well-being of the town, but who have not as yet succeeded in getting their plans or schemes adopted by the Central Council.⁸⁶⁴

The “principle of freedom” to experiment had already been afforded to “manufacturers”, who were allowed to “manage their affairs in their own way, subject, of course, to the general law of the land, and subject to the provision of sufficient space for workmen and reasonable sanitary conditions.”⁸⁶⁵ The garden city model was most closely modeled upon the privately organized but publicly regulated industry in Britain, as well as the spatial planning and building regulatory powers of municipalities in Wilhelmine Germany.⁸⁶⁶ As in both of those cases, neither “the complete municipalization of industry”, nor the “elimination of private enterprise” were necessary for “preparing the ground for an experiment as is here advocated”, nor were they the ultimate goal of the experimental work.⁸⁶⁷ Instead, experimental garden cities, each one conducting its own municipal experiments just as competing industries experimentally derived their own standards, would be used to “drive into the very bedrock of vested interests”, on both extremes of the

⁸⁶³ Ibid., 94.

⁸⁶⁴ Ibid., 87.

⁸⁶⁵ Ibid., 26.

⁸⁶⁶ Ibid., 114. Reflecting the close link between Britain and Germany at the time, Howard turned to a quote from Goethe, in which the poet called for “action”, and not only “reflection”, as the route towards self knowledge and social responsibility, further reinforcing the active process of experimentation.

⁸⁶⁷ Ibid., 68.

political spectrum, a “great wedge, which will split them asunder with irresistible force, and permit the current legislation to set strongly in a new direction.”⁸⁶⁸

While in practice, Howards’ theories of municipal experimentation proved more difficult to achieve at Letchworth Garden City, the idea of a settlement serving as a national experiment would be realized at Hampstead Garden Suburb. Here Unwin first worked with MP John Burns to prepare the Hampstead Act of 1906, allowing him to suspend existing spatial planning regulations at that settlement in order to experimentally derive and standardize new methods, which were then documented in *Town Planning in Practice*.⁸⁶⁹ Hampstead would serve as a working model for the kind of physical fabric and political and economic agency that Burns and Unwin had hoped to extend to all of Britain’s local councils, through the passage of the Town Planning Act of 1909.⁸⁷⁰ As Unwin explained, the earlier principles of the “movement (had been) too theoretical and experimental to appeal very widely to the English people”⁸⁷¹; a physical demonstration had therefore been needed. At Hampstead he had been able to “experiment with” a number of elements, such as “roads of various characteristics and widths”⁸⁷², afforded by the passage of the 1906 Act.

The earlier “garden villages”, established by Mr. Cadbury at Bourneville, and Mr. Lever at Port Sunlight, had not only extended *the principles of organization* from the industrial plant to the settlement, but they had benefited from a certain autonomy vis-à-vis

⁸⁶⁸ Ibid., 136.

⁸⁶⁹ Creese, *The Search for Environment: The Garden City, before and After*. Kenneth D. Brown, "Burns, John Elliott (1858–1943)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004).

⁸⁷⁰ Unwin discussed the passage of this act in the 1909 manual and in Raymond Unwin, "Introduction to the Second Edition," in *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1911).

⁸⁷¹ *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs* (London: T Fisher Unwin, 1909), 3.

⁸⁷² Ibid., 376.

building regulations, as they were located outside of urbanized areas.⁸⁷³ Howard, in his writings, and Unwin in practice, had essentially sought to marry the freedom of large industry with that of the model of municipal planning already in practice in Wilhelmine Germany. At Hampstead, a site that had been recently incorporated into Greater London but was also legislated as a space of inquiry, Unwin had the opportunity to “experiment... on a larger scale”; a privilege he shared with other architects and “various Co-partnership Tenants Societies”.⁸⁷⁴ The idea of the settlement as a municipal and national experiment directly impacted the “experimental settlements” program in Germany.

The Settlement as “Practical Experiment”, Martin Wagner, 1925

Equipped with a thorough familiarity of the English garden city movement and its theories, as well as access to Unwin’s manual, in German, starting in 1910, Hermann Muthesius was able to further elaborate and develop upon these English ideas in his own publications, lectures and projects, as numerous scholars have shown and I have outlined further in Chapter 1. It was Muthesius who would theorize the “villa colony”, not only as a design problem to be solved through building with types (or in series), but more importantly as the optimal space of inquiry for the evolution of types, using Norman Shaw’s “experiment at Bedford Park” as a model for typification work.⁸⁷⁵ It was also Muthesius who would later suggest that the principles of scientific management might finally achieve social equilibrium, as well as innovation and economical efficiency, within the framework of Germany’s cooperatively owned building societies, a sentiment shared by Frank

⁸⁷³ "Introduction to the Second Edition." Also discussed in Creese, *The Search for Environment: The Garden City, before and After*.

⁸⁷⁴ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 376.

⁸⁷⁵ Hermann Muthesius, *The English House, Volume I: Development*, trans. Janet Seligman (London: Frances Lincoln Ltd., 2007 (1904)). See Chapter 1.

Gilbreth.⁸⁷⁶ It would be Muthesius' former employee, Martin Wagner, who would promote the principles of scientific management, and particularly the visualization theories and instruments developed by Gilbreth⁸⁷⁷, to German cooperative building societies in Germany, as well as provide examples of the application of this approach in America and Holland, along side garden city *classics*, between 1921 and 1925.⁸⁷⁸ (Fig. 133) In 1925, May would use this knowledge of the laboratory method to discuss what he would call "practical experiments".

Wagner first discussed the need for "practical experiments" in 1925,⁸⁷⁹ when he announced the recent formation of the DEWOG, a research organization funded by the Free Trade Unions and affiliated with *Bauhütte*, an association of cooperative building societies.⁸⁸⁰ To fulfill DEWOG's mission, Wagner founded GEHAG, a non-profit entity which would support the establishment of a "practical experiment" at the settlement scale, through the establishment of the Hufeisensiedlung Britz, where it would be "possible to

⁸⁷⁶ "Wirtschaftliche Baubetriebsformen (Systematically Managed Building Methods)," in *Kleinhaus Und Kleinsiedlung* (Munich: F. Bruckmann A.-G., 1920). See Chapter 1.

⁸⁷⁷ Through his work as the *Stadtbaurat* of Schöneberg on the *Grosssiedlung* Lindenhof, between 1918-20, Wagner became the first architect to apply Frank Gilbreth's bricklaying system methods to a settlement design project in Europe. As Wagner himself often correctly acknowledged, the construction of Lindenhof's 500 housing units were systematically, not scientifically, managed, since he primarily applied an already derived standard method to a settlement planned mostly in the manner of the German Irregular School. (Fig. 134) Martin Wagner, "Vom Eigenen Werk. (Siedlung "Lindenhof" in Berlin-Schöneberg.)," *Wohnungswirtschaft* 1, no. 1-2 (1. April 1924). The project is briefly discussed in *Martin Wagner 1885-1967: Wohnungsbau Und Weltstadtplanung*. (Berlin: Akademie der Künste, 1986). and in Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's*.

⁸⁷⁸ In 1924, Taut also published one of the first examples of motion study applied to a housing unit organization in Germany. "Wie Soll Der Kleinwohnungsbau Der Minderbemittelten Volksklassen Finanziert Werden?," *Wohnungswirtschaft* 1, no. 3 (1 May 1924): 22. (Fig. 135) This analysis, which would later be published in a number of American architectural journals uninterested in the work of the Gilbreths, was primarily deductive, with the geometry of the plan informing the study, and not the process of conception, construction and settlement, which the laboratory method called for. This reverse translation is discussed in Hyungmin Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America* (Cambridge: The MIT Press, 2000).

⁸⁷⁹ Martin Wagner, "Rationalisierter Wohnungsbau," [Rationalized Dwelling-building.] *Soziale Bauwirtschaft* 5, no. 20 (15 October 1925).

⁸⁸⁰ The *Deutsche Wohnungsfürsorge A.G. für Beamte* (DEWOG) was founded by Wagner, Bruno Taut and Richard Leincke on March 14, 1924.

extend the studies of systematically managed building” into all areas of *dwelling-building* (housing delivery) and to generate cost data, which could be used in the future to economize housing delivery.⁸⁸¹ (Fig. 136) Wagner explained that he was “fully aware that in the first phase of construction of five hundred units at Britz, significant success in cost reduction would not be achieved” and that significant savings would only possible “in the later phases”.⁸⁸² While he acknowledged that this kind of “uncertain experiment”, costing seven million marks, could be construed as the “most dangerous kind of dilettantism”, he reassured his readers by applying Taylor’s theoretical methods to the prime model of American industrial success, the Ford Motor Company.⁸⁸³ The significant cost reductions achieved by that company “had not been achieved by the fact that Ford drew a particularly cheap type”, but had instead been generated through the close study of the “fabrication process of this type” in real time.⁸⁸⁴ “No Ford”, Wagner explained, “would release a design of an automobile on paper” into “mass production” without first studying the actual fabrication of a “cheaper model”, and moreover, the fabrication process itself, to identify interdependencies and “idle times”.⁸⁸⁵ For Wagner, “in housing, the situation is not different”, with the “idea... held by laypeople and professionals alike ... that one only needs to typify the dwelling unit and each plan variant as efficiently as possible” on paper being

⁸⁸¹ Wagner first discussed John Conzelman’s work in Youngstown, Ohio as a study of housing delivery along a “practical and experimental basis” in “Was Müssen Wir Tun Um Den Volkswohnungsbau Zu Verbilligen?,” *Wohnungswirtschaft* 1, no. 17/18 (1. Dezember 1924): 164. He then used the same terminology in “Rationalized Dwelling-Building”, pointing to his Hufeisensiedlung as the primary example in Germany. Here he used the same language that would eventually be included in the RFG’s name, systematically managed or systematized, building and dwelling methods, derived through scientific management of practical experiments, or what the RFG would call experimental settlements.

⁸⁸² Wagner, “Rationalisierter Wohnungsbau,” 270.

⁸⁸³ Ibid. While Wagner mentions Ford here, he consistently discusses Gilbreth’s methods.

⁸⁸⁴ Ibid.

⁸⁸⁵ Ibid.

“completely wrong”.⁸⁸⁶ Much like the argument made in the previous chapter, Wagner astutely articulated that it was not the “invention” of “a new shoe type” or an entirely “new shape of brick”, which had made American industry so superior, but rather the “way that the fabrication process as a whole was organized”.⁸⁸⁷ At the GEHAG settlement in Berlin, Wagner acted as *Bauregisseure*, or “building choreographer”, and Bruno Taut acted as settlement and unit designer.⁸⁸⁸ Wagner and Taut’s work at Britz would serve as another important precedent for Walter Gropius and Ernst May, both of whom had joined Wagner and Taut as part of the DEWOG’s *Kopfgemeinschaft*, or “think tank”, in 1924, hoping to receive funding for their own *practical experiments*.⁸⁸⁹

The Rationalization of Intellectual Work, Wilhelm Lübbert, 1926

While both Walter Gropius and Ernst May showed a general interest in applying the laboratory method to settlement-building, and even began this process in early 1926 before the RFG was even formed, they anticipated that this experimental work would necessitate, as well as garner, scrutiny both from themselves, as well as from others. This was particularly true for May, whose own position within the municipal government offered certain advantages, but also ensured more scrutiny, and whose experimentation with fabrication techniques led to further assessments by material scientists at two of

⁸⁸⁶ Ibid.

⁸⁸⁷ Ibid.

⁸⁸⁸ Here, between 1925 and 1927, they applied Unwin’s organizational schemes at the settlement design scale and Gilbreth’s brick and concrete systems for construction management, while also documenting data using instruction cards, gantt charts and progress photos. In addition to this masterful use of already standard settlement design and construction management techniques, Taut applied his own unique expressionist sensibility, less *medievalizing* than in their earlier work at Lindenhof and more tempered by the persistent influence of English domestic architecture. The nickname *Bauregisseure* was given to Wagner by his good friend, Hans Poelzig, according to Berhend Wagner, *Martin Wagner 1885-1957: Leben Und Werk* (Hamburg: Wittenborn 1985), 19.

⁸⁸⁹ Mentioned in Wolfgang Voigt Claudia Quirling, Peter Cachola Schmal, Eckhard Herrel, ed. *Ernst May: 1886-1970* (Munich: Prestel, 2011). May and Gropius prepared their own experimental work, in late 1925 and early 1926, in hopes that the DEWOG might fund it.

Germany's leading technical universities. Between 1927 and 1929, at least a dozen architects and engineers affiliated with the RFG made visits to both experimental settlements, filing various reports that were later synthesized into the April 1929 publications, in which the criticisms were anonymous. The most consistent figure in all of these assessments was Wilhelm Lübbert, the appointed head of the experimental settlements program. He prepared the general criteria with which the experimental settlements were to be evaluated, leaving the actual evaluation to others.⁸⁹⁰ Much of these criteria had already been outlined in Lübbert's 1926 book, *Rational Dwelling-building: Type/Norm*.⁸⁹¹

In his discussion of norms and types, Lübbert reasserted a number of already familiar arguments. He acknowledged Germany's dire postwar situation, but also repeated the earlier argument of the Werkbund, regarding German design, in the forms of standards, being competitive on the "global market". He also reiterated the prewar admiration for English housing and American industrialization.⁸⁹² Lübbert also argued that the term *Typisierung*, or "typification", was still not clearly defined and concluded that what

⁸⁹⁰ These criteria are included in the cover pages of the extensive report on each the experimental settlements, published in April 1929. Four individuals signed these criteria, Lübbert, as well as Paul Mebes, and the two non-architects highest ranked in the RFG, Riepert and Emil Weber. As I will demonstrate, much of the language is most consistent with Lübbert's earlier writings.

⁸⁹¹ Wilhelm Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]* (Berlin: Arbeitsgemeinschaft für Rationalisierung im Bauwesen/Beuth Verlag 1926). The official publisher of the DI-Norms was the *Beuth Verlag*. At this time, Lübbert was the member of the recently formed National Committee on Types, the predecessor to the RFG. The experimental settlements program was already discussed and even proposed by October 1926, well before the RFG was actually founded.

⁸⁹² *Ibid.*, 7-9. Lübbert advocated for suburbanization along the general lines of the garden city movement, explaining that the "English (remained) superior" in delivering "small and medium sized housing units". Like Muthesius, in *Kleinhaus und Kleinsiedlung*, he explained that the Great War had reinforced the prewar desire, on the part of the public, to "escape from (the) 'rocky desert of the metropolis' and to live in healthy single family homes with allotment gardens". As a result, the postwar "housing shortage" had to take into account the public's preference for the "single family house". He also pointed to the organizational principles of American industry to produce "more and better things... with the use of the same manpower (and) the same expenditure of natural resources and energy".

distinguished a type from a norm was that while “building components and entire structures” may have “typical forms”, they are not normed until their “individual dimensions were ... fixed.”⁸⁹³ Following this logic, he argued that while a type could be “dimensionally specified, or normed” it could not actually be “typified” or “typed”; a type could either be identified or invented, it could not be made more typical.⁸⁹⁴ The distinction being made here was no longer a purely theoretical one, as it had been for Hermann Muthesius, but a practical one; Lübbert was in a position to define government policy on what had been previously referred to as typification and type-building by Muthesius or experimentation and standardization by Le Corbusier. While the practice of identifying types or inventing could remain vague, the practice of norming, which included prescribing specific dimensional and other parameters, needed to be *normalized*.⁸⁹⁵

Lübbert would essentially repeat Muthesius’ own critiques of the architectural discipline, from 1914 and 1918, and argued that changes needed to occur if the architect was to be involved in mass housing delivery, as well as the norming of building components and unit types.⁸⁹⁶ The “designer architect” now had to evolve into the “house computation engineer”, who was less interested in developing “design ideas and artistic

⁸⁹³ Ibid., 15-16.

⁸⁹⁴ Ibid. “Man kann einen Typ schaffen und diesen Typ normen. Man kann jedoch nicht irgend etwas, irgendeine Bauform "typisieren". Der Typ ist da oder wird erfunden und in seinen Maßen festgelegt, d. h. genormt.”

⁸⁹⁵ Ibid., 16. For Lübbert, the definition of a type remained more vague, but was nevertheless the prerequisite for norming. Norming consisted of “exact measures”, or the creation of “dimensional norms”, for the spatial planning and construction of a dwelling, From this, additional norms defining other “qualities” could be set, such as the appropriate relationship of one space to another, thermal properties, solar exposure, cross ventilation, as well as the details to be used and equipment to be installed, in other words, specifications.

⁸⁹⁶ Ibid., 11. Prior to the Great War, the “real architect” had worked only on “large residences”, while 80-90% of the “small and medium housing” was designed and built by contractors. As a result of the contractor’s reliance on “inadequate technical training” and “poor pattern books” for his designs, “ugly and inefficient” structures were produced. This method had replaced the Typenbau approach, where the master builder created a simple organizational sketch to be interpreted by his crew, on site, and further informed by local conditions and traditions. Since it was not “possible to re-establish traditional building”, the model of the “pure *Baukünstler*” had to be replaced with a new kind of architect.

intentions on paper” and more willing to “strive to refine (a) more optimal house through a process of gradual technical improvement”.⁸⁹⁷ This new figure would need expertise both in the “management of the construction process” as well as in finance. Furthermore, it would require one to become more engaged in the formulation of “new building regulations and city-expansion plans”, as well as the development of new design techniques for “more efficient site design” and “better infrastructure and parcel layout”.⁸⁹⁸

After describing a new role for the architect, Lübbert turned to a consideration of what initiatives should be lobbied for by the discipline and managed by non-governmental agencies, like the DNA. He listed three related areas for increased rationalization; the *rationalization of intellectual work*, the *rationalization of the construction site* and the *rationalization of off-site production* of building components, the order reflecting the degree to which the architect was already positioned to participate, as well as which would have the greatest impact.⁸⁹⁹ The “rationalization of intellectual work” included the preparation of drawings and other specifications, as well as an idea as to how these instruments would optimize the intellectual work of other architects and disciplines as they worked on the further “norming of building materials, assemblies, floor plans layouts, entire structures, cost estimates, material specifications, accounts and financial plans”.⁹⁰⁰ By eliminating “(t)his unproductive work on paper”, architects would again have more time for conjecture

⁸⁹⁷ Ibid. “*entwerfenden Architekten*” and “*Hausbau ingenieur*”.

⁸⁹⁸ Ibid.

⁸⁹⁹ Ibid., 12-16. In 1914, Gilbreth translated standardization as *Normalisierung* or norming. *Rationalisierung* became more widely used during the twenties.

⁹⁰⁰ Ibid., 14. Lübbert pointed to the “hundred thousand units of housing built after the War” that had been based on “at least ten thousand designs, each with their own area and structural calculations, cost estimates, building inspections, mortgages, special fire insurance, etc.”, to reinforce the need for this type of rationalization.

through “creative building activity”.⁹⁰¹ Through the rationalization of intellectual work, the “rationalization of production facilities” and the “rationalization of the construction site”, a “more efficient use of materials, (prefabricated) assemblies, labor and time”, would be informed.⁹⁰²

Lübbert also broke down the “function and ultimate goal of norming” into three steps.⁹⁰³ The first included the identification of types, the dimensional norming of their parts and the specification of their qualities, ideally through “creative building activity” and not just through *paper* investigations.⁹⁰⁴ This was the step that the experimental settlements program would fill. Second, these documents would offer, but not necessarily dictate, norms to “municipalities, mortgage lenders, cooperative buildings societies and all other entities” involved in housing delivery, and would allow the construction industry to establish facilities for the “efficient mass production of components and entire structures” following the American model of fabrication.⁹⁰⁵ The third step was more of a general forecast, reminiscent of Muthesius’ theories of typological evolution and adaptation, with the continued process of the application of norms, as tentative standards, “over time”, helping to improve the norms themselves, as well as offering greater economy and quality to the products they regulated.⁹⁰⁶

Lübbert was also explicit that the new scale of architectural work, in terms of housing, was no longer the unit, but the settlement. With more rationalized instruments and methods of intellectual work, the architect could shift focus from the study and

⁹⁰¹ Ibid., 24. “Diese unproduktive Papierarbeit muß sich in die Tätigkeit des eigentlichen Gestaltens und schöpferische Bautätigkeit wandeln.”

⁹⁰² Ibid., 14.

⁹⁰³ Ibid., 16. “Zweck und Ziel der Normung”

⁹⁰⁴ Ibid.

⁹⁰⁵ Ibid.

⁹⁰⁶ Ibid.

“grouping of a few rooms into a small and medium dwelling plan” to the grouping of already normed structures”, following a “few functional floor plans” and normed “building components” into *Wohnhausgroup* and *Siedlung* scale ensembles.⁹⁰⁷ The “forming (of) beautiful groupings, through the aggregation of individual units” was the new creative task of the architect, one that was not only superior to the earlier quest for “thousands of (individual plan) solutions” that sought to “group a few rooms into a residential floor plan, simply for the sake of novelty”, and that led to production of entirely new drawing sets, calculations and permits.⁹⁰⁸ The experimental settlement would facilitate this creative norming activity.

The ‘Experimental Settlements’ Program and the RFG, 1926-1931

During the interwar period, a number of programs were proposed and carried out, in both the United States and Europe, with the goal of developing more optimal building components, construction methods and housing organizations.⁹⁰⁹ The RFG’s experimental settlements program was unique in its emphasis on experimentally deriving and standardizing systematic building and dwelling types and norms through the process of settlement building. Building upon earlier work in America, France and Germany, the program went the furthest in applying the laboratory method to architectural production.

Gropius and May’s experimental settlements not only constituted an increased

⁹⁰⁷ Ibid., 24.

⁹⁰⁸ Ibid.

⁹⁰⁹ Grosvenor Atterbury had proposed a research program to the Hoover administration, but they felt that the university engineering departments were already adequately addressing this issue. Mentioned in Peter Pennoyer and Anne Walker, *The Architecture of Grosvenor Atterbury* (New York: W W Norton & Co., 2009). Lewis Mumford called for the establishment of a “council of experts” to “hasten the rationalization of the modern house” by providing a “dozen standard plans”. He assumed that this would be generated deductively, not experimentally. Lewis Mumford, “Mass-Production and the Modern House,” *The Architectural Record* (1930): 16. Raymond Unwin, named chief housing architect of the Ministry of Health in 1918, had supported the foundation of the Building Research Board, now known as the Building Research Establishment, in tandem with the passage of the Housing and Town Planning Act of 1919. Andrew Saint, “Unwin, Sir Raymond (1863–1940),” in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004).

rationalization of existing methods or a demonstration of a particular technique⁹¹⁰, as had been the case in earlier examples, but they were truly the site of knowledge production, just as Bethlehem Steel had been for Taylor and Gantt or NE Butt and Auer had been for the Gilbreths.

The RFG was a part of what David Nelson has called Weimar Germany's "seamless web ... of quasi-public agencies"⁹¹¹, which were all involved in standardization and loosely coordinated by NADI, as well as by a number of other professional associations, industry groups and entities.⁹¹² The most direct predecessor to the RFG was the *Reichstypenausschuss*, or "National Committee on Types", formed on June 16, 1926.⁹¹³ Most of the initiators of the experimental settlements program and the RFG, including non-

⁹¹⁰ *Betondorp*, or "Concrete Town", a portion of one of Amsterdam's new "garden cities", *Watergraafsmeer*, is a good example of a demonstration project. Initiated by Ary Keppler, the head of municipal housing services, in 1922, and funded through low interest loans afforded by the *Woningwet* Act of 1901, this project sought to demonstrate, more than research, the viability of applying nine different concrete building systems to housing. A number of factors limited the role of the architects working on this project. As the basic town plan, housing types and building systems had all essentially been fixed, the architects were left to resolve the basic internal organization, foreshadowing the limited and specialized role of the architect in postwar housing delivery. In terms of scientific management and the state, or even the municipality, the conception, construction and settling of the first phase, between 1923 and 1926, reinforced something that was already fairly obvious, which was that for this low to midrise housing fabric, the only warranted system was that of concrete block, informing the final phase to rely primarily on those systems. For more on *Betondorp* see Helen Searing, "Betondorp: Amsterdam's Concrete Garden Suburb," *Assemblage* 3(1987).

⁹¹¹ Nelson, "Introduction."

⁹¹² The RFG was associated with the German Architects Association (BDA). The "experimental settlements" program relied on existing prewar Wilhelmine-era housing programs, as well as new initiatives, such as increased municipal expropriation powers and veterans mortgage loans programs introduced in response to the dire postwar situation. One of the precursors of the RFG was the *Reichshochbaunormung*, a subcommittee of NADI formed in 1919 to develop standards for the building of industrial facilities. In 1920, that NADI subcommittee issued its first *Kleinhausbau* standards for doors and windows. That same year another NADI subcommittee, the *Reichsverbandes für sparsame Bauweise*, began to consider, not only components but also construction methods. By 1926, the expanded scope and heterogeneous structure of NADI, now no longer limited to industrial products, led to a renaming of the organization to the *Deutscher Normenausschuß* (DNA), or German Standardization Association. The RFG was part of that expanded work. The *Beuth Verlag*, formed in 1924 to publish the DNA's DI-Norms would also publish the RFG reports. The most thorough discussion of the RFG published to date is included in Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*.

⁹¹³ The National Committee on Types, formed through the direct support of Heinrich Braun, the SPD Minister of Labor, consisted of twenty-one members and sixteen deputies, and was further organized into two subcommittees focused on technology and systematization.

architects Marie-Elisabeth Lüders, Hans Riepert and Max Bahr, as well as architects Wilhelm Lübbert, Friedrich Paulsen, Otto Bartning, Bruno Ahrends and Walter Gropius, were members of this Committee.⁹¹⁴ Gropius, Lüders and Lübbert were the most vocal advocates for experimental settlements, convincing the association to prepare a proposal to the Reichstag for a thousand units of experimental housing in the amount of ten million marks in October 1926, and gaining approval in December 1926.⁹¹⁵

During the first half of 1927, a subcommittee of this organization, headed by Wilhelm Lübbert, with two non-architects, Bahr and Lüders, and five architects including Paulsen, Bartning and Gropius, as well as two new additions, Arnold Knoblauch (1879-1963) and Paul Mebes (1872-1938), evolved into the RFG, which was formally founded on June 29, 1927 and registered on January 21, 1928.⁹¹⁶ The RFG would include a Board of Directors, headed by Hans Riepert, with Marie-Elisabeth Lüders serving as Deputy Director. Both the board and the advisory council, also formed at this time, were heavily weighted with architects.⁹¹⁷ On February 1, 1928, the RFG signed a contract with the Dessau Municipality, to convert an already funded settlement, Törten in Dessau, into an experimental settlement. The contract stipulated that the planning, construction and

⁹¹⁴ Marie-Elisabeth Lüders was the association's highest ranking politician and representative of the recently restructured DNA, Hans Riepert (1874-1939) was the representative of the German Cement industry and the future director of the RFG, and Max Bahr (1848-1930) was the most senior member of the association and a textile industrialist. The architects were: Wilhelm Lübbert, Walter Gropius, and Friedrich Paulsen, the editor of *Bauwelt* who had introduced Behrens to scientific management.

⁹¹⁵ Wagner had received seven million marks for 500 units at Britz. Wagner, "Rationalisierter Wohnungsbau."

⁹¹⁶ This subcommittee visited Dessau, where the first phase of construction had already been completed in February 1927.

⁹¹⁷ At least one-third of the board members were architects, including Otto Barthning and Friedrich Paulsen, as well as new members, Hans Rauch, Eduard Siedler, Rudolf Stegemann and Martin Wagner. The board was complimented by an advisory council, Chaired by Paul Mebes, with Walter Gropius serving as Deputy Director. The council was similarly dominated by architects, including Walter Curt Behrendt, Fritz Block, Alexander Klein, Ernst May, Bruno Paul, Otto Rudolf Salvisberg, Wilhelm Stober, Paul Schmitthenner, Bruno and Max Taut, Heinrich Tessenow and Gustav Wolf; while members of the council, such as Gropius and May, could also receive funding, members of the board could not.

settling of 256 “experimental units” would be documented with the instruments of scientific management in exchange for additional financial support from the RFG. On February 28, a second contract was signed with the Frankfurt Municipality to support laboratory work related to the conception, construction and occupation of 900 experimental units, using Ernst May’s Frankfurt System of fabrication and assembly. In both cases, the funding did not cover the cost of land or construction, but only the laboratory work, which would involve the studying of the units, by both representatives of the RFG, the municipality and other institutions over the next ten years, through various post occupancy studies. The experimental settlements program would also extend to two other settlements, including the *Weißenhofsiedlung* in Stuttgart, whose settlement plan was designed by Ludwig by Mies van der Rohe, and of which only the four already completed multi-unit housing units, designed by Mies van der Rohe, Peter Behrens, Mart Stam and J. J. P. Oud, would be analyzed.⁹¹⁸ Since all three of these settlements were designed in a modernist idiom, a number of Germany’s more conservative architects, such as Paul Schultze-Naumburg, complained of an aesthetic and political bias to the program.⁹¹⁹ Emil Weber, a non-architect and executive board member, responded to these criticisms by insisting that the RFG’s focus was developing techniques for the “systematic management of building and dwelling” and that “artistic-building” issues were “outside of the scope” of the association.⁹²⁰ However, this criticism led to the support of a fourth experimental settlement in Munich, which was less explicitly modernist in its expression and consisted of

⁹¹⁸ Due to the limited scale and scope, the subsequent analysis of this project does not use the term “experimental settlement” in its title. "Bericht Über Die Siedlung in Stuttgart Am Weissenhof," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Sonderheft Nr. 6, no. Gruppe IV, Nr. 3 (April 1929).

⁹¹⁹ Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*.

⁹²⁰ The later reports generally avoided a specific discussion of language, but they did consider the perception of the users as well as spatial planning issues in addition to fabrication and construction.

114 units constructed for postal employees.⁹²¹ Overall, neither the scale, nor the degree of experimentation, of the projects in Munich and Stuttgart, approached that of the work in Dessau or Frankfurt, where the number of experimental units equaled that of the three other projects combined. All four of these settlements were evaluated throughout 1928 by teams of experts, with their initial findings being published in four detailed, book-length reports, in April 1929.⁹²²

In February 1927, the Ministry of Labor pressured the RFG to stage an “experimental settlement” in Berlin, and by the summer of 1928, a new kind of space of inquiry, a *Forschungssiedlung*, or “research settlement”, was planned in Spandau, a suburb of the German capital.⁹²³ In September 1928, a RFG team prepared a “program” outlining the research work to be conducted through the Spandau-Haselhorst settlement, which would serve as the basis for a public competition.⁹²⁴ In January 1929, a primarily RFG member jury, as well as Mayor Czeminski, awarded the first prize to Walter Gropius and Stephan Fischer,⁹²⁵ but the project was never developed beyond this phase.⁹²⁶

⁹²¹ Organized as a single perimeter block, approximately 200 by 200 meters in size, this project was the only one of the four to have actually started after the formation of the RFG, with planning occurring during the summer of 1927 and construction occurring between the spring and fall of 1928. While, some of the experimentally derived standards of the earlier settlements were further developed, such as the Frankfurt Kitchen now in the guise of the Munich Kitchen, this project generally lacked the iterative trial and error qualities of Gropius and May’s work. “Bericht Über Die Versuchssiedlung in Munchen [Report of the Experimental Settlement in Munich],” (Berlin: RFG, April 1929). The work here clearly influenced Ernst Neufert’s Building Machine project of 1943, published in his second manual, Ernest Neufert, *Bauordnungslehre (Building Regulation Methods)* (Berlin: Volk und Reich Verlag, 1943).

⁹²² The four reports ranged in length from 130 to 150 pages. The foreword, explaining the experimental nature of the work, written by Lübbert, was nearly identical in each case, while the rest of the content varied significantly.

⁹²³ “Reichswettbewerb Zur Erlangung Von Vorentwürfen Für Die Aufteilung Und Bebauung Der Gelandes Der Forschungssiedlung in Spandau-Haselhorst,” *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Sonderheft Nr. 3, no. Gruppe II 1 (February 1929).

⁹²⁴ The jury included Lüders, Behrendt, Lübbert, May, Mebes, Riemer, Siedler, Wagner and Weber.

⁹²⁵ In their comments, the jury praised “the scientific rigor” of the scheme, embodied in the author’s decision to offer “four different variants of settlement scheme side by side, without necessarily defining what is the most systematic solution.” While there was some indication that the specific variant would be defined at a later date, the jury rejected two of the four schemes, with Scheme C being criticized for “going above the

By early 1929, the RFG modified its membership and expanded the number of subcommittees and initiatives beyond the experimental settlements program, including a subcommittee on *Grossstadtwohnung*, or “metropolitan dwellings”, and another on *Kleinswohnung*, literally translated as the “smallest dwellings”.⁹²⁷ Some of the other programs were initially established to develop more general standards from the experimental settlements work⁹²⁸, following the model set by the production of DI-Norms, but soon, a number of members began to question the need for experimentation in social space, arguing that standards could be rationally deduced, by experts,⁹²⁹ as exemplified in the work of Alexander Klein (1879-1961).⁹³⁰

Klein had been tasked by the RFG with assessing the completed work at Weißenhofsiedlung, as well as the “collection of typical floor plans of already executed buildings”, primarily in Berlin.⁹³¹ In a 1927 article, titled “An Experiment Using a Graphical Method For Evaluating a Small-House Floor Plan”, Klein demonstrated the use of a graphic

desired building height” and Scheme D for ignoring the “local terrain”. Schemes A and B were most similar in terms of the distribution of density to settlements already constructed by two of the jurors, Ernst May and Wagner, as well as by Walter Gropius himself, but unlike many of these schemes, here, one of Unwin’s diagrams had been deployed with little or no modification to site conditions or with an eye for “individuation”.

⁹²⁶ Scheme C is the clear model for Minoru Yamasaki’s Pruitt-Igoe Housing Complex in St. Louis (1950-1954). In its criticisms in 1930, the jury predicted many of the problems that would plague that project.

⁹²⁷ This term would later be replaced by “existence minimum”.

⁹²⁸ In addition to “surveys of the completed ‘experimental settlements’ of the RFG, at *Stuttgart-Weißenhof*, *Frankfurt-Praunheim*, *Dessau-Törten*, *München-Arnulfstrasse*” and the “Jurying of the results of the Spandau-Haselhorst competition”, the RFG now engaged in the “collection of typical floor plans of already executed buildings”, “Work 1-6 bedroom housing unit types”, “Work on the particular areas of systematic plan design, such as the (optimal) number of rooms, circulation, etc.”, the “Establishment of an “experimental space” for floor plan design development” and, finally the “Formation of definitive versions of the most efficient house types”.

⁹²⁹ One of the most vocal proponents of this approach was Ludwig Hilberseimer. Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's*, 218.

⁹³⁰ Klein’s work is discussed as a model of scientific management applied to architectural work in Pai, *The Portfolio and the Diagram: Architecture, Discourse and Modernity in America*. Klein’s approach impacted the development of public housing organization in America, during the thirties.

⁹³¹ Klein’s numerous positions on a number of RFG committees is documented in “Ausschuss 2 - Vorhandene Bauten - Tätigkeitsbericht,” *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Mittelungen Nr. 30, no. Gruppe II 2 Nr. 1 (April 1929).

projection system nearly identical, in appearance, to the “routing plans” that Frank Gilbreth had developed, between 1914-15, during his work for Auer in Berlin.⁹³² (Fig. 137) Klein argued that in the “usual evaluation of ... plans, whether from competitions, proposals or completed buildings, a number of concepts and terms, such clarity, economy, spatial form, spatial sequence, circulation, area utilization, overall impression, etc., are repeatedly used”, by professionals and laypeople alike. He found these terms overly “subjective in meaning”, and sought to define a more “universal, objective (method of) examination” of the floor plan.⁹³³ He then proceeded to demonstrate his technique through the analysis of Oud’s row-house scheme at the *Weißenhofsiedlung*.⁹³⁴ He analyzed the scheme through a series of graphic projections, including a non-spatial graph documenting the relative floor areas of the different program elements, or “floor-plan element(s)”. Additionally, he prepared a series of plan projections that studied the placement of thresholds between spaces, furniture and core elements, the specific sequence of programs, the *Verkehrswege*, or “paths of circulation”, and the “*verlauf der Ganglinien*”, or “extension of the routes”, actually implied desire and site lines, the drawing most similar to Gilbreth’s routing plans.

From these instruments of analysis, Klein hoped to develop more “objective” instruments of projection, a process he outlined in three steps. First, the architect would arrange the “paths of circulation and the desire and site line”, essential for the *Bewirtschaftungsmöglichkeit*, or “systematic management of space”, as well as bringing *Einfachheit*, or “calm”, to the future dweller. This would then allow the architect to

⁹³² Alexander Klein, "Versuch Eines Graphischen Verfharens Zur Bewertung Von Kleinwohnungs Grundrissen," *Wasmuths* (April 1927).

⁹³³ Klein uses the term *objektive*, not simply *sachlich*. As a number of scholars have recently argued, the translation *sachlich* as “objective” is incorrect. Francesco Passanti, "The Vernacular, Modernism, and Le Corbusier," *Journal of the Society of Architectural Historians* 56, no. 4 (December 1997).

⁹³⁴ "Bericht Über Die Siedlung in Stuttgart Am Weissenhof."

“concentrate the areas of movement” and group furnishings to enclose space. Using these studies, the architect would then consider the “geometric similarity and interrelation of floor-plan elements”, which would be studied in more detailed sequential perspectives, some of which were also included in the article. This step would further manage how the space would be “interpreted uniformly (by a subject) upon entering a room”, as well as inform the “overall impression of the apartment” by the dweller, “consciously or subconsciously”. While the 1927 work still relied on some empirical evidence, albeit analyzed primarily through a geometric surrogate, an article published in 1928 titled “Contribution to the Housing Question”, went further towards developing an entirely geometric system, only loosely based on empirical evidence. Here, instead of working from one of the RFG coordinated experimental units, Klein instead analyzed a more typical Berlin apartment building, using the basic parameters derived from that analysis to then generate a new, supposedly more efficient type, based primarily on the same analytical tools.⁹³⁵(Fig. 138) He then went one step further, offering a “rational” system for deriving a variety of floor plan variants.⁹³⁶ (Fig. 139) While Klein’s graphic projection tools did constitute a potential method for more consistently evaluating the results of various architectural projects through the analysis of their floor plans, one that could be used in the service of experimental work, he did not use these instruments to assist laboratory work,

⁹³⁵ Alexander Klein, "Beitrage Zur Wohnungsfrage," in *Probleme Des Bauens*, ed. Fritz Block (Potsdam: Müller & Kiepenheuer, January 1928). Here, Klein would outline his own method in even greater detail, using the same basic graphic techniques demonstrated in 1927, but now applied to both an existing Berlin floor plan and to one of his more spatially and psychologically efficient floor plan schemes. The editor of the publication, Fritz Block, was also a member of the RFG and would lead the assessment of May’s experimental work in Frankfurt.

⁹³⁶ Ibid. Klein proposed a “scheme for the rational floor-plan building for any desired type in different housing conditions”. The “scheme” included a basic unit composed of two basic structural bays and access to a single circulation core, expanded horizontally and vertically into ninety possible permutations, twenty-eight of which were deemed feasible and were developed in greater detail.

but in lieu of it. This equation of observation, when assisted with instruments developed to assist in experimentation, as experimentation itself, was not unique to Klein. As Peter Galison has explained, this equation, Positivism, was common in a number of fields, including science, during the twenties.⁹³⁷ While Gropius and May would not necessarily be entirely free of this tendency, they did go to great lengths to stage experiments in conception, construction and dwelling outside of the controlled environment of the atelier or the institute, in social space.

Not only was the experimental settlements program unique to the RFG, from which only half of the supported settlements achieved what could be called a laboratory method approach to architectural production, but it was terminated prematurely, due primarily to the Stock Market Crash of 1929, which would exacerbate an already difficult economic situation in Weimar Germany. Despite a very active 1929, the new Minister of Labor, Adam Stegerwald, reduced the RFG's scope from experimentation to research⁹³⁸, cutting short Ernst May's ongoing work in Frankfurt and canceling preparations for the "research settlement" at Spandau. But even this reduced role was short lived and the entire RFG was disbanded a few months later, in 1931. Nevertheless, the data and methods experimentally derived and standardized at the four experimental settlements would travel with a number of German émigrés, both west to the United States and east to the Soviet Union. Ernst

⁹³⁷ Peter Galison, "History, Philosophy, and the Central Metaphor " *Science in Context* 2(1988). Galison has argued that the appearance of positivism, essentially the confusion of observation for experimentation, in science in the 1920s, was "paralleled ... in art, architecture and politics" with the "early tracts of the logical positivists resemble far more the daring pronouncements of the Italian Futurists, or the Russian Constructivists, than they do the more philosophical fare of the British Hegelians or the German and Austrian neo-Kantians."

⁹³⁸ Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*, 253.

Neufert would also utilize the RFG research in his two manuals on the planning of occupation and construction, although he failed to credit the association.⁹³⁹

Walter Gropius and the Dessau-Törten Experimental Settlement, 1926-1929

The initiative, financing and general program for the experimental settlement at Törten, near Dessau, preceded the move of Walter Gropius, along with the Bauhaus, in 1925.⁹⁴⁰ (Fig. 140) In fact, the head of the municipal council, Fritz Hesse, used this project to help lure the school to Dessau. The RFG's financial support for the experimental work here subsidized the project nearly a year and a half after it was approved and financed by the municipal council, on June 24, 1926, a week after the National Committee on Types had been formed in Berlin.⁹⁴¹ The first phase of experimental work at Törten (September 1926 - February 1927), which consisted of sixty identical units, therefore preceded the formation of the experimental settlements program and the RFG. The second phase of the project, which consisted of another one hundred units, began after the proposal for the experimental settlements program but was nearly complete by the time of the RFG's formation in January 1928. When funding, as well as a more specific program of experimentation, for 256 "experimental units", was issued on February 1, one hundred of the units had already been constructed, leaving the conception, construction and

⁹³⁹ Ibid. Gernot Weckherlin, "Ernst Neufert's Architects' Data: Anxiety, Creativity and Authorial Abdication," in *Architecture and Authorship*, ed. Katja Grillner and Rolf Hughes Tim Anstey (London: Black Dog, 2007).

⁹⁴⁰ While somewhat distant from the school's future site, this site benefited from proximity to a regional train station, Dessau Sud, views of the Mulde River, as well as easy access to electrification provided by a recently completed electrical line infrastructure, a site feature that would appear as prominently in Gropius' later drawings of the settlement as medieval walls or Roman viaducts had in Unwin's sketches of irregular towns. Since the land was located approximately three miles from the school, student and faculty housing, this future settlement would not necessarily house the Bauhaus community, but it could certainly serve as an outdoor classroom for experimentation, a living laboratory.

⁹⁴¹ Most of Törten Dessau was financed through the National Homesteads program, started in 1924 to offer low interest loans for the construction of affordable housing, in the form of owner-occupied single family houses and garden plots. Financing – 350,800 RM total, of which 256,000 RM would pay for the interest on a 30 year loan for each of the 256 units, 44,800 for planning and documentation and 50,000 for capital costs of purchasing equipment. Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*.

settlement of 156 units, as the primary *material* for the most laboratory method-like phase of the project, conducted between April 1928 and January 1929.⁹⁴²

The “experimental building site” (1922) and the “experimental settlement” (1925)

The concept and even the specific term *Versuchssiedlung*, or experimental settlement, was influenced by a number of earlier ideas I have already discussed, but was also specifically linked to the evolving pedagogy of the Bauhaus itself. The fusion of the spaces of production, education and dwelling was a theme that had been common since 1919.⁹⁴³ That idea was also visible in the first Bauhaus Siedlung proposal in 1922, designed by Fred Forbat and Walter Gropius for a site in Weimar.⁹⁴⁴ (Fig. 141) That same year, Gropius prepared a diagram of the Bauhaus curriculum and pedagogy.⁹⁴⁵ (Fig. 142, 143) Organized as a series of rings, the diagram included common core courses given during the first semester, more advanced courses, as well as specializations in working with various materials pursued over a three year period, rotating around a set of terms which functioned as a spoke: “building”, “the building site”, “the experimental (building) site”, and

⁹⁴² This last phase also came after Gropius visited the United States, in May 1929. Of the total 314 units at Törten, the 156 that were the most closely studied by both the architect and *RFG* inspectors, whose findings would be published in a report in April 1929.

⁹⁴³ At that time the school saw itself as a medieval *Bauhütte*, a community of artist-craftsmen whose working and dwelling would be closely connected within a single urban unit. Leah Dickerman Barry Bergdoll, ed. *Bauhaus, 1919-1923: Workshops for Modernity* (New York: MoMA, 2010).

⁹⁴⁴ In May 1922, Fred Forbat, a Fischer-trained architect, and Walter Gropius, prepared a more developed settlement scheme for a site in Weimar. Here Forbat, more so than Gropius, would demonstrate a level of familiarity and mastery of Unwin’s manual, defining a clear primary and secondary center, and traffic corridors, around which standard units formed distinct architectural, street and place groupings. Unwin’s techniques allowed Forbat to simultaneously distinguish the school’s constituencies and integrate them as collectives of individuals around common spaces, organizing the ‘masters’ in nineteen single family houses, younger faculty and senior students in fifty-two row houses, and housing more junior students around the primary center in a multi unit quadrangle-like building. In this scheme, the workshops were treated in a more matter-of-fact fashion, where a series of seven similar structures were placed between the settlement and one of the primary traffic arteries, on the northeastern edge of the site. Fred Forbat, “Brga.12.1 Bauhaus Housing Development “Am Horn,” Weimar, 1920-1922: Site Plan,” (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1922).

⁹⁴⁵ July 1922. (Fig. 142) Similar to H. L. Gantt and F. W. Taylor C. G. Barth. 753,840 Slide Rule. USA, March 8, 1904 (Application Filed Nov. 20, 1901). (Fig. 143)

“research of building and engineering issues”.⁹⁴⁶ The notion of the settlement, and not only the building site, as the optimal site of architectural experimentation is more evident in 1925, when Gropius exclaimed that “there (were) cooperative experimental building sites to be established!” With his initial focus in Dessau on the school complex as well as the master’s houses, his first “experimental settlement” would not begin until the summer of 1926.

Gropius’s experimental program at the Törten Siedlung in Dessau, 1926-1929

A text published in June 1926, offers valuable evidence of Gropius’ intentions and priorities on the eve of his experimental work at Dessau, and bears a resemblance to that of Frank Gilbreth’s list format instruction cards, such as the *Bricklaying and Concrete Systems*.⁹⁴⁷ The first step discussed here was that of the mass production of serialized building components off-site, in specialized factories. The following three steps all called for the application of time and resource saving technologies to construction, as well as space and energy saving equipment to residences, the “rationalization of building management” through the use of standardized building components at the unit scale, and the use of standard methods and instruments of project management, borrowed from

⁹⁴⁶ “Therefore, the field of education to all sides must be towards extended to related areas so that the impact of new experiments can be tested in uninterrupted sequence. Of crucial importance is the education of the children, because it must be started with the youngest, of raw material.” From Walter Gropius, *Idee Und Aufbau Des Staatlichen Bauhauses Weimar* (Weimar: Bauhaus Verlag, 1923). The topics included in the spoke were not only intended as the apogee of a students study, with “building” as a theme and the “experimental building site” as a space for synthesis, but also as a permanent atmosphere in which the students would be surrounded from their first day of study. The conceptual and formal logic of this diagram is identical to the radial slide rule. C. G. Barth. 753,840 Slide Rule. According to Mauro F. Guillen, *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture* (Princeton: Princeton University Press, 2006)., Gropius first wrote extensively about Taylor and Gilbreth in 1926. He had already been exposed to the Taylor System as early as 1910, as one of Behrens’ employees.

⁹⁴⁷ Part of a speech given to the Dessau Municipal Council, later published in a city newspaper. In Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*. Gropius was certainly already familiar with Gilbreth’s work through Wagner’s journals. Like Gilbreth’s systems, these lists would change as the work progressed, with some steps moving in the order, new ones appearing and some being removed entirely.

industry, and applied to the settlement scale through construction plant plans. These adapted project management plans, were to be used in a subsequent step, namely managing the cost of money itself, a crucial issue in Germany's context of hyperinflation.⁹⁴⁸ This list of principles would evolve and expand throughout the experimental process, providing a useful insight into the architect's own shifting priorities.

Törten Phase I

The first phase of experimentation at Törten (June 1926-January 1927) relied on three sets of what Le Corbusier would call *established standards*, an Unwinian organizational scheme for a group of buildings around a T-intersection, at the settlement scale⁹⁴⁹, and two related building components, a hollow concrete block, similar to the one used by Behrens in 1918, used to construct perpendicular load bearing walls, and reinforced concrete beams, used to span across the hollow concrete block walls and serve as the primary element of the floor and roof decks. (Fig. 144) The third established standard used at Törten, the row-house type itself, drew on a normed "Hausform" included in Wilhelm Lübbert's 1926 publication.⁹⁵⁰ (Fig. 145) The particular architecture for this project, as well as new norms, would be generated through experimentation and standardization work that relied on these three established standards.

Gropius' planning, management and data collection during Phase I would be assisted by a number of graphic projection instruments. The most synthetic instrument was a hybrid settlement plan/industrial plant plan/construction plant plan he would variously label simply as a *Siedlungsplan*, or "settlement plan", or as a "plan for the rational

⁹⁴⁸ The experimental settlements program and the National Homesteads program, the two primary funding sources for Törten, were both financed through loans made by the German government.

⁹⁴⁹ Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 332,33.

⁹⁵⁰ Lübbert, *Rationeller Wohnungsbau: Typ/Norm [Rational House-Building: Type/Norm]*, 105.

organization of the construction site – building season 1926”.⁹⁵¹ (Fig. 146) This plan would be used in conjunction with a series of progress photos documenting the fabrication and construction work, taken weekly during the fall of 1926.⁹⁵² (Fig. 147, 148) At the intermediate scale between row-house unit and street grouping, Gropius utilized a study model, through which he could consider the assembly of the unit itself.⁹⁵³ (Fig. 149) Lacking his own experimentally derived data, to help plan the scheduling and routing of fabrication and assembly, Gropius borrowed a gantt chart of a previously constructed settlement project, published in one of Wagner’s journals.⁹⁵⁴ (Fig. 150) At some point during Phase I, or possibly in preparation for Phase II, Gropius projected a *Zeitplan*, or “time plan”, for “rough construction during the 1926 building season”, which was actually a modified gantt chart that included some aspects of Gilbreth’s process chart methodology.⁹⁵⁵ (Fig. 151) The use of this instrument was unique to Törten, with Gropius

⁹⁵¹ “plan für die rationelle Einrichtung der Baustelle Baujahr 1926”, Fritz Block, ed. *Probleme Des Bauens [Problems of Building]* (Potsdam: Muller und Kiepenheuer (Bund Deutscher Architekten), 1928), 207. This drawing was not included in the first article on the project in *Das Neue Frankfurt*. While the primary source of this grouping was Unwin’s 1909 manual, here the more direct precedent is Forbat’s 1922 scheme for the Bauhaus Siedlung, a title that would also often be applied to Törten.

⁹⁵² Weekly photos of the progress were taken during Phase I. Two of these photos are held at Harvard University, Walter Gropius, “Kg316 Building Site,” (Harvard University: Loeb Library, Harvard Design School, 1926), a third was published in “Der Grosse Baukasten,” *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 2 (December 1926). Gropius also commissioned aerial photos of the project, at least even internally. One of these was later included in *Bauhausbauten - Dessau*, vol. 12, Bauhausbücher (Munich: Albert Langen, 1930), 142.

⁹⁵³ A photograph of the model, “BrGa.22.64,” (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, Undated (1926)), and a study of the color scheme, “BrGa.22.7 Isometric Construction Scheme,” (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, Gift of Walter Gropius, 1926). Are held at Harvard University.

⁹⁵⁴ Gropius used an “Arbeitsgraphikon”, a more conventional gantt chart of an already completed settlement project included in a discussion of “scientifically managed construction task” written by Otto Rode, an Austrian engineer in Otto Rode, “Wissenschaftliche Arbeitsmethoden Im Baugewerbe,” *Soziale Bauwirtschaft* 4, no. 1 (1 Jan 1924): 52. Gropius would include this chart along with his *Zeitplan* and photos of Törten in his lectures at Harvard University. Walter Gropius, “Kg316z Settlement Dessau-Törten, Dessau, Germany,” (Harvard University: Loeb Library, Undated).

⁹⁵⁵ Block, *Probleme Des Bauens [Problems of Building]*, 257. Like any instruction card or gantt chart, this graphic projection instrument included a sequence of fifteen sub tasks outlining the planned “rough building” work, in this case, the first task being to “erect the construction plant”, which was planned to take two weeks. The y-axis indicated time, in months and in blocks of eight units; the block had become the primary measure

developing an even more advanced version of this information technology in 1928, following his return from his travels to the United States.

The first product of these graphic projection and project management instruments was the set of drawings for permitting of what would later be called Type I.⁹⁵⁶ (Fig. 152, 153) A two-story duplex row house unit, the type's compact mass was linked with and broken down towards an allotment garden, which was visible and accessible from a kitchen connected to a living room.⁹⁵⁷ While Lübbert's 1926 type measured seven by eight meters on the ground floor and about half that on the upper level, as it was tucked into the pitched roof, Gropius' flat roof unit measured 5.7 x 7.14 meters on both the ground floor and upper level. In order to facilitate a more versatile grouping of the unit into *streets* and *places*, as compared to Lübbert, Gropius shifted the entry from the sides of the duplex toward the front of the building, creating a small court-like space, similar to one of Behrens' earlier configurations.⁹⁵⁸ (Fig. 154)

Just as the unit plan was designed with the intention of helping Gropius manage his conception of the settlement as a whole, the "plan for the rational organization of the building site" served as an instrument for the planning and managing of fabrication and construction. He began the process with the more carefully managed and studied

of progress. The two axes together projected two related curves for each block, the first curve showing the start times of each task and the second curve showing the expected completion dates. This graphic projection helped visualize the interrelationships of construction influencing a particular group, such as the completion of foundations in order for the erection of party walls to begin, as well as the interrelationships between groups, such as a crane being freed up to assist in the assembly of reinforced concrete beams. It seems unlikely that this tool was used in day-to-day management, but probably served as a planning and recording instrument. In 1928, a new type of Zeitplan would be used to manage work on a weekly basis.

⁹⁵⁶ "Bericht Über Die Versuchssiedlung in Dessau," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).

⁹⁵⁷ All three of the types derived at Törten would include carefully designed allotment gardens. (Fig. 161)

⁹⁵⁸ Gropius, "Der Grosse Baukasten," 27 By Type IV this choice would lead him to push up the front of the building a half level – increasing privacy and creating a more complex *Raum*-plan-like interior. This decision was also driven by construction experience.

construction of four units, or two duplexes, then using this experience to help plan and manage the remaining seven groups of eight units, or four duplexes. The small *place*, one of Unwin's T-junction configurations, served as the casting yard for the rapid reinforced concrete floor joists, which would move along the line of the future street, awaiting assembly by a tower crane, which also moved along the same tracks.⁹⁵⁹ The larger reinforced concrete lintels, spanning over the window openings, were cast right in front of their intended building. The rail track linked depots of lime, as well as small onsite quarries of sand and gravel to pulverizing and mixing machines. The processed materials then moved along two more rail lines, which ran parallel to the street tracks along the sites of the future allotment gardens, to casting yards, where the concrete blocks were stamped, cured and stored, until assembly, which would occur only a few meters away.⁹⁶⁰ The entire Phase I process, documented through drawings, photographs and film, was presented in December 1926 to the public, with the experimental settlement construction site serving as a live demonstration of Bauhaus pedagogy.⁹⁶¹ (Fig. 155)

In December 1926, Ernst May offered Gropius a chance to reflect on the experiences of the first phase of his experimental work, through an article in the recently launched *Das Neue Frankfurt*.⁹⁶² These experiences led to the expansion and revision of his earlier, June

⁹⁵⁹ The more centralized and mechanized approach to rapidly curing beams was perfected in later phases of the project, significantly increasing the efficiency and economy of the whole process. Here, the choice of where to invest in terms of technology proved more informed than at Pessac.

⁹⁶⁰ The overall organization drew heavily on Gilbreth's *Bricklaying* and *Concrete System*, with the rail infrastructure and crane functioning like Gilbreth's scaffolds, and with the construction plant plan ensuring that the raw materials and partially finished building components were optimally placed in space and time.

⁹⁶¹ Gropius, *Bauhausbauten - Dessau*, 12, 174-75.

⁹⁶² "Der Grosse Baukasten." The article was placed alongside the first German-language publication of Le Corbusier's "laboratory of industrialization, standardization and Taylorization" and May's first article on his own Frankfurt System of industrialized housing delivery. Gropius' text also repeated a number of points about the roles of the architect, the builder and the entrepreneur he discussed in "Programm Zur Grundung Einer Allgemeinen Hausbaugesellschaft Auf Kunstlerisch Einheitlicher Grundlage M.B.H.," *Ausgewahlte Schriften* (1910).

1926 *instruction card* from five to thirteen subtasks. (Fig. 156) Instead of off-site fabrication, now the first task was the definition of a “farsighted land use policy and long term (financial) planning”.⁹⁶³ Additionally, two more settlement design issues were added; the “systematic separation of traffic corridors and residential streets” and the definition of “socio-economically beneficial” green infrastructure, both at the settlement scale, through public parks, and the unit scale, through allotment gardens.⁹⁶⁴ The next two steps related to the definition of types, in which the architect needed to define the particular “socio-economic appropriate form of housing”, either “an apartment, a row-house, a duplex, or a single family house”, as well as determine the “socio-economically appropriate” floor plan organization for that type.⁹⁶⁵ Only then could the architect engage in the “typification and norming of the whole house and its parts”.⁹⁶⁶ Once this more disciplinary work was complete, the architect could turn to “applying” existing “space and material saving technologies and building components”, as well as solicit the fabrication of some of the building components that he himself had normed from specialized factories.⁹⁶⁷ Then, the planning of the “rational systematic-building-management of the construction site” could be conducted through the consideration of “assembly work routed with a *Zeitplan*”, resulting in savings in both material and labor usage, as well as in the interest paid on loans. This temporal motion planning would inform the preparation of a “rational construction plant plan”, which was intended to be resolved as carefully as a “mechanical

⁹⁶³ "Der Grosse Baukasten."

⁹⁶⁴ Ibid.

⁹⁶⁵ Ibid.

⁹⁶⁶ Ibid. Gropius would insist that the whole house should not be normed in 1929.

⁹⁶⁷ Ibid.

drawing”.⁹⁶⁸ Shifting from systemization to aesthetics, Gropius further promised that this approach could lead to a “unity of the greatest variety and the greatest typification”, providing that only “building components”, rather than “whole houses”, were typified, which would allow for “variable assembly”, at the architectural and settlement scales.⁹⁶⁹ Whereas he had opened with the importance of “generous and farsighted land management”, he closed with a call for “far-sighted fiscal policy” in order to support municipalities, builders and tenants.⁹⁷⁰ To Gropius, the same set of principles, which had supported the “thousands of kilometers of trenches” during the Great war, were similarly required for the “defense of the family and the health of the (German) people”, an issue that was no “less important”.⁹⁷¹

Törten Phase II

Encouraged by the Reichstag’s positive response to the experimental settlements program in October 1926, and in preparation for a visit by a number of the programs representatives, including Lübbert and Weber, in February 1927, Gropius finally prepared a settlement design scheme for the entire municipally owned site.⁹⁷² With no additional funding provided to the site by the beginning of the 1927 building season, Gropius prepared a much less expansive plan for the “second building phase”, focusing new

⁹⁶⁸ Ibid. By utilizing these methods, one would be better prepared to contend with the inevitable contingencies of construction, such as bad weather, or material or labor shortages.

⁹⁶⁹ Ibid.

⁹⁷⁰ Ibid.

⁹⁷¹ Ibid.

⁹⁷² That scheme essentially repeated the street grouping scheme as a pattern across the site, a design move that reflected Gropius’ lack of settlement design training or experience, as compared to Forbat or May, both of whom had studied with Theodor Fischer. The design proposed three radial streets consisting of free-standing duplexes, all variations of the 1926 street group but oriented north-south instead of east-west, overlooking the bluff of the Mulde River and south of a primary road and electrical viaduct connecting the train station to a planned public promenade along the rivers edge.

construction primarily along the east-west traffic corridor in May.⁹⁷³ For this phase, Gropius prepared a new unit plan, Type II, reorganizing the basic elements to form a larger overall unit, similar in depth but wider in frontage, which resulted in a simpler overall geometry, as well as more opportunities for cross ventilation, insolation and a better entry sequence.⁹⁷⁴ (Fig. 157) The hundred “experimental units” of Phase II, primarily following the Type II layout, were mostly completed by the time the municipality and RFG signed a contract on February 1, 1928. While Phase II was probably the least experimental, as well as the least documented of the three phases, it nevertheless informed the third and most important phase of the experimental settlement, defining the 360 centimeter module that would be used for the remainder of the project.⁹⁷⁵ (Fig. 158)

Törten Phase III

During Phase I and Phase II, Gropius was given greater freedom to interpret what constituted an experimental settlement. With the February 1928 contract came a series of more specific stipulations as to how the work should progress, as defined by the RFG. To more objectively evaluate specific methods, choices of building components and unit types at Törten, the RFG required Gropius to establish two control groups as well as two new experimental streets to further develop the methods derived in the first two phases. The

⁹⁷³ Both schemes are included and discussed in detail in Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*. They would inform the final scheme (Fig. 159).

⁹⁷⁴ Instead of 5.7 x 7.14 the new type was 7.8 x 7.2 meters. The new type fixed a three hundred sixty centimeter clear dimension between walls. This reconfiguration provided better internal organization, as well as greater opportunities for cross ventilation and insolation. The change in massing also increased the size of the entry court space shared by the two units, resulting in a more undulating street façade and a calmer garden façade, a reversal of the previous silhouette and rhythm of the Phase I street front. In terms of expression, both of the structural elements, the concrete block wall and the reinforced concrete beams, were now delineated in a darker color, whereas infill walls were painted white.

⁹⁷⁵ These modules were photographed before the non-load bearing walls were inserted, Walter Gropius, "Brge.22.85," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, Undated). Gropius reinforced this distinction through the Type II paint scheme, as visible in "Brge.22.33," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, Undated).

first of these, Group 15, consisted of ten Type II units, constructed with standard bricks by the same teams of builders. The second control group, Groups 13 and 14, consisted of sixteen units, which would serve in the experimentation for the fabrication and assembly of a new type, Type IV, before it was further studied and standardized at the settlement scale. This last step would be organized along two experimental streets, the first made of forty-four Type II units and the second of eighty-six Type IV's. Group 8, the last and therefore most refined group of the Type IV's, would be studied even more closely, using a combination of instruction cards, conventional gantt charts, Gropius' new *Zeitplans* and progress photos. Here, Gropius would also experiment with mechanized wall painting. In conjunction with this final phase, Gropius also revised the overall settlement plan during the winter of 1927/28.⁹⁷⁶ (Fig. 159)

The experimental work at Törten began with Type I, which was based loosely on Lübbert's published type and modified to better facilitate grouping at the settlement scale and the use of new materials at the building component scale, as well as to follow the still emerging aesthetic sensibilities of modernist architecture. Type II was a more refined product of the experimentation and standardization work applied to Type I. At the group scale, Type II generated a more broken building line with more defined entry courts, while at the unit scale, the fixed 360 centimeter clear dimensions between the walls was used as a module to *systematize* the space and time of fabrication and construction, particularly the erection of floor and roof decks, as well as that of dwelling, as visible in the two children's

⁹⁷⁶ "Bericht Über Die Versuchssiedlung in Dessau." The plan follows the logic of the earlier February and May 1927 schemes.

bedrooms on the second level.⁹⁷⁷ Like Le Corbusier's Domino System, as well as his units at Pessac, Gropius had now developed an organizational unit that was smaller than a unit and larger than a building component, allowing for greater efficiency in producing architecture at the scale of the settlement and the building component, simultaneously.⁹⁷⁸ (Fig. 160, 161)

The planning of the future space of occupation of Type IV, informed by the experiences conceiving, constructing and settling the previous two Types, was conducted in tandem with a series of experiments that examined the validity of the chosen combination of building components and the construction and assembly methods, conducted through the production of Groups 14 and 15, between April and June 1928. The hollow concrete block perimeter walls had proven to be efficient through the earlier phases, but the use of the block as non-load bearing infill was seen as uneconomical and a series of experiments suggested that thin *Bimsbeton*, or "pumice concrete", could be used instead.⁹⁷⁹ (Fig. 162) Experiments were also conducted to potentially replace the cast

⁹⁷⁷ A number of characteristics first introduced in Type II, including a slight jog in the roofline, a simpler foundation without a cellar, as well as the more consistent use of the three hundred and sixty centimeter module, informed Type IV (Type III was skipped). This new organizational tool is visible in the decision to reintroduce a cellar under the front full modules, which faced the traffic and crane corridor, ensuring greater efficiency in erecting the concrete elements laid by the crane during construction and once settled, offering greater privacy to the street-side bedroom units. This resulted in a single row of bedrooms between the mirrored units of the duplex/row-house grouping and a combined ribbon window, broken only by the protruding concrete block party walls, as had been the case with Le Corbusier, with his "cube of air" also set by a standard window assembly dimension.

⁹⁷⁸ The standardization work is most clearly visible through a comparison of the Lübbert type, the Conzelman row house and the three types developed at Törten. The external expression of the unit's internal logic also evolved. In Types I and II, Gropius emphasized the division between the load bearing perpendicular walls and the infill walls, through coloration, while in Type IV, he applied a more unified white painted stucco finish to the entire surface, contrasting it with the window assemblies and the polychromic interiors, visible through his "northern", "factory" or "ribbon" windows.

⁹⁷⁹ A number of alternative concrete mixes were investigated before settling on *Bimsbeton*, or "concrete mixed with pumice dust", due to its improved thermal insulation properties. Fly ash- and slag-strengthened concrete, were also considered. A similar concrete mix was also being used by Ernst May at this time, albeit in a larger format and as structural elements. These studies are visible in a series of progress photos from 1928, including Walter Gropius, "Brga 22.83," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum,

concrete beams and joists, used in the floors and roofs of the units, with more standard wooden floor construction or by a lost concrete tile process. These were abandoned once the on site fabrication of these components was finally optimized.⁹⁸⁰ During this time, Gropius staged his first micro-motion studies of the customized hardware of some of the standard steel-frame ribbon windows being used at the site.⁹⁸¹(Fig. 163) He also experimented with the mechanized painting of the unit interiors in the more elaborate polychromic schemes developed to counter the muted white exteriors of the Type IV's.⁹⁸² (Fig. 164) While not all of the studies were equally successful, the various scaled models and full-scale mockups, studies of perception and of movement in time, at the scale of the

1928)., and Friedrich Kuhr Walter Gropius, "Brga.22.4 Dessau-Törten, 1926-1928: Color Scheme for Walls and Ceilings," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1928). (Fig. 162) At Törten, smaller panels were chosen after larger panels proved to cure unevenly, creating cracks in the stucco façades of some of the Type II units. This *error*, a natural part of the laboratory method and one that was acknowledged by Gropius and discussed in the 1929 RFG report, was nevertheless used to critique the very premise of "experimental settlements" as wasteful and irresponsible endeavors in the January issue of *Wasmuths*. (Fig. 162) "Neue Baukunst Und Wohnungspolitik," *Wasmuths* 1(January 1929): 4. Schwarting points to a similar attitude in the local Dessau press, Schwarting, *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*, 212.

⁹⁸⁰ Andreas Schwarting has shown that the fabrication process of the roof and floor joists, "rapid beams", was one of the most successful examples of industrialization at Törten, developed closely with the manufacturer of the molding technology. *Die Siedlung Dessau-Törten: Rationalität Als Ästhetisches Programm*, 227. In contrast to Edison's or Atterbury's approach to industrialized housing delivery, which began with a technological "invention", this approach truly followed the laboratory method, with an established standard being transformed through experimentation and standardization in the space of production, the "experimental settlement". (Fig. 165)

⁹⁸¹ "Bericht Über Die Versuchssiedlung in Dessau," 51-52. Similar studies of the Bauhaus building and the masters houses are included in Gropius, *Bauhausbauten - Dessau*, 12.

⁹⁸² The mechanized painting, through a spraying mechanism, proved viable in the initial experiments, just as sprayed on concrete seemed viable to Le Corbusier during the construction of the Maison Du Tonkin. The further standardization of this technique, at the settlement scale was more challenging, with this laboratory work significantly delaying the completion of Phase III, a process that would otherwise flow smoothly. Interior elevation studies, Walter Gropius, "Brga.22.4 Dessau-Törten, 1926-1928: Color Scheme for Walls and Ceilings.", and Werner Isaacsohn Walter Gropius, "Brga.22.5 Dessau-Törten, 1926-1928: Color Scheme for Walls and Ceilings," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1928)., as well as worms eye view isometrics, of Type II, Friedrich Kuhr Walter Gropius, "Brga.22.3 Dessau-Törten, 1926-28: Interior Color Scheme, Isometric," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1928)., and Type IV, Werner Isaacsohn Walter Gropius, "Brga 22.6 Dessau-Törten: Building Type 4, Interior Color Scheme (Isometric)," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1928)., demonstrate this shift from an exterior demarcation of structural logic to a more complex treatment of color as another independent element.

unit and the settlement, technical drawings and micro-motion photographs, all contributed to visualizing and projecting the laboratory work at Törten.

This work at the unit scale, conducted on paper and through the “experimental house” Groups 13 and 14, was conducted in parallel with the planning of the temporary construction plant and final groups of eighty-six Type IV and forty-four Type II units, along two curving streets, at the settlement scale. To assist in the planning and management of this creative typing and norming work, carried out between April 1928 and January 1929, Gropius utilized a series of visualization instruments, including more conventional instruction cards, gantt charts and progress photos, whose use had been explained in Wagner’s journals, as well as a new version of the Zeitplan he had used to manage and study his work in 1926. All of this would be coordinated by a settlement-scale construction plant plan, eloquently titled the “organization plan”.⁹⁸³ (Fig. 166) While informed by the earlier construction plant plans used by Gilbreth, Conzelman and other examples, included in Wagner’s journals, Gropius’ plan exhibited a much more intricate synthesis of spatial and temporal issues regarding fabrication, assembly and occupation, in a single projection instrument.⁹⁸⁴

The “organizational plan” included scheduling as well as routing information, following four distinct flows around the site and defining the positions of equipment and materials. Whereas his earlier “plan for ordering the construction site” (1926) served primarily as a planning tool, this new instrument was used more iteratively as a

⁹⁸³ "Bericht Über Die Versuchssiedlung in Dessau," 105. Gropius would simultaneously plan the permanent infrastructure for the settlement, at the settlement, street and unit scale. (Fig. 167)

⁹⁸⁴ Only Ernst May would match and exceed the synthetic nature of Gropius’ “organization plan”.

management tool, and was updated every week to reflect the “status of work”.⁹⁸⁵ This comprehensive instrument, a *precise space-time visualization*, indicated the completed structures, in black, the two streets, three centralized areas for the fabrication of concrete, reinforced concrete beams and lime stucco, as well as four flows of materials, connecting off-site material depots, the centralized fabrication zones and the fabrication and assembly zones along the streets themselves into a single *temporary plant*. The scale of the work now warranted the construction of a temporary *Bauburo*, or “field office”, at the center of the site, as well as a fixed *Foto Blick Punkt*, or “photographic station”, on the roof of one of the complete Type II groupings, located immediately adjacent to the last of the Type IV groups, Group 8. In terms of sequence, the first element regulating the process was the “raw material supply route”, which was drawn in a heavy black line tracing the flow of raw materials from outside of the site, along the recently completed Type I street, before separating into three distinct flows, each servicing one of the centralized fabrication sites. The first of the three fabrication sites included an area for the concrete block stamping machines, as well as fields for their curing, overlapping, but carefully coordinated, with the staging areas for two groups of Type II’s. The second route, the “construction site materials route”, indicated as a double dot dash line, moved the blocks within the fabrication facility and then on to the center of the Type II street and part of the Type IV street, before moving on to support the second centralized fabrication facility for the rapid concrete beams, set between two experimental streets. The rapid concrete beam facility extended nearly the full length of the space between the two streets, consisting of a concrete mixing plant, a

⁹⁸⁵ The plan included in the RFG report showed the state of the temporary construction plant on June 25, 1928. Whereas the 1926 temporary construction plant had taken two weeks, the much larger 1928 plant, which would support the fabrication and assembly of more than double the units, would take much of June 1928 to prepare.

series of casting fields, a workshop and storage for reinforcing elements. The same construction site materials route connected this facility to the third route, the two “crane routes” for each of the two streets. While the first route indicated the movement of motorized vehicles, and the construction materials route showed the position of a more permanent track, the “crane route” showed the temporary position of the heavier rail track which supported the movement of the two tower cranes in later June, placed along Groups 5 and 6, consisting of Type IV’s, and Group 12, consisting of Type II’s.⁹⁸⁶ The last of the centralized fabrication sites, where the stucco for the facades was fabricated, was located on the far east edge of the site, with flow to the location via the raw material and construction site materials route and flow of the mixed stucco, via the fourth and final route, “the lime stucco route”, which led to a series of “lime pools” positioned to support work on the two streets.

Following the protocols of the RFG, Gropius also utilized both drawings, as well as variants of the Gantt chart and instruction cards, appropriately varied in “size and form”, to document Phase III.⁹⁸⁷ (Fig. 168) Type IV had been organized into a series of thirty subtasks, ranging from the excavation of the foundation to the finishing of the interior and exterior surfaces.⁹⁸⁸ (Fig. 169) The finest temporal scale mapped by these instruments was

⁹⁸⁶ According to the detailed progress photos of the project, the crane tracks were moved to their final locations during the week of July 16-21.

⁹⁸⁷ As Frederick Taylor had explained in 1903, the “instruction card was ... to the art of management what the drawing is to engineering, and, like the latter, should vary in size and form, according to the amount and variety of the information which it is to convey.” Accompanying the building component, unit, street and settlement scale drawings were an equally varied set of individual and gang instruction cards, stipulated by the RFG in their contract with Dessau municipality. These instruments would serve, first and foremost to record the laboratory work. While there was certainly a belief that they would also potentially increase efficiency, this was a secondary concern.

⁹⁸⁸ The 1926 *Zeitplan* had included fifteen sub tasks of “rough work”. The final version of this gantt chart was published in “Bericht Über Die Versuchssiedlung in Dessau.” The chart itself, Walter Gropius, “Brga.22.122 Chart,” (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1928)., and the chart, showing

the day, and a week was the primary unit of measure.⁹⁸⁹ These gang instruction cards, or gantt charts were used to plan and manage work. In the chart used to track Group 8, the last group in the sequence, rain-days caused delays to the start and finish of a task four times, including the delay in the arrival of roofing materials to the site by four days, the delay of the arrival and installation of plumbing by fourteen work days, the delay of the arrival of wood flooring by fourteen days and finally the month-long delays in the interior and exterior finishing of the units. In order to assist in this work, another instruction card variant with the thirty tasks and the different groups printed on a blank grid was used to track daily progress. For Group 8, the group that was intended to demonstrate the optimal standard method, progress photos were taken every two to three days, from a consistent spot, allowing for a more detailed assessment of progress and documentation of motions, for later study by Gropius and the RFG.⁹⁹⁰ (Fig. 170-173)

In addition to employing a full range of standard management instruments, Gropius developed a new version of his 1926 *Zeitplan*. (Fig. 174) This new *Zeitplan* mapped time, in weeks and days along the x-axis, and progress in tasks, measured in groups and units, along the y-axis. Three “curves” were projected onto the lines of the Type IV portion, the first curve, “a”, showing the start of work, the second, “b”, showing the “theoretical completion time”, and the third “c” showing the “actual completion time”, with the lines of the group work that exceeded theoretical time also dashed. Type II included five curves, with the two additional curves indicating the completion of different levels. In Type II, the efficiency of

the actual work completed, "Brga.22.113 Chart," (Harvard University: Harvard Art Museum/Busch-Reisinger Museum, 1928)., demonstrate how this instrument was utilized in 1928.

⁹⁸⁹ The only exception was the interior and exterior surfaces, which took four weeks.

⁹⁹⁰ Another set of cards was prepared for use by the contractor, outlining the beginning and end dates of each of the groups, the unit types and the number of units.

task repetition, and thereby the increased skill of all involved, is visible in the last curve, “h”, with the derivation of completed from planned dropping over time. The same phenomenon is even more visible in the Type IV, where the repetition and further optimization of the same standard methods led from a delay of seven weeks in Group I to a delay of three weeks, entirely explainable by rain and off site fabrication delays outside of Gropius’ control, by Group VI. The more significant delays in Groups 7 and 8 were caused by Törten’s last experimental work, the investigation of mechanized painting.

RFG’s Assessment of Törten, April 1929

The RFG, as well as its predecessor, the National Committee on Types, had organized a number of examinations of Törten between February 1927 and January 1929, publishing these in a report in April 1929.⁹⁹¹ The introduction, signed by Riepert, Weber, Mebes and Lübbert, emphasized that this was only a provisional assessment, since the “experimental structures had only been completed and occupied for a few months”.⁹⁹² Here the tentative nature of the experimentally derived standards was also emphasized, explaining that the process of standardization should continue to be “experimented with”, in “other places with different conditions and climates” before they would be endorsed as RFG standards. The introduction also speculated on how to balance the need for experimentation, through practical experiments, with the associated cost of this work. The

⁹⁹¹ Several members of the RFG visited Törten, including Lübbert, Weber and Klein. Block was appointed by the advisory council to lead the production of the actual report. He was assisted by Otto Meyer-Ottens, an architect, Bauhaus instructor and Hamburg’s postwar head of city planning, and Hans Kammler, an engineer, part of the extreme right *Rossbach Freikorps* in 1919, and future Nazi Party member and SS officer.

⁹⁹² The report indicated plans for further analysis over the next decade of the buildings’ performance through later inspections and post occupancy surveys, as the contract between the association and the municipality had dictated.

same general discussion was repeated in all four of the reports issued in April 1929.⁹⁹³ There was a distinct preference for *Zeilenbau* planning throughout the report, leading to a critique of Gropius' design for its lack of optimal solar orientation, at the settlement and unit scales.⁹⁹⁴ In a number of cases, the critique also relied on initial post occupancy surveys. For example, while the smaller *Bimsbeton* panels seem to have significantly improved the thermal performance of the unit envelopes, residents complained of drafts caused by the poorly installed window assemblies, at least partly the fault of Gropius' detailing. The report was enthusiastic about Gropius' production of novel visualization instruments, the *Zeitplan*, at the settlement scale, but complained about the lack of "time and motion studies" at the scale of the unit construction. Here, the RFG reviewers made no specific argument as to what these studies would improve, and may have simply been motivated by what Guillen had termed the "organizational aesthetic", the belief that by simply applying the visualization methods of scientific management, one would increase efficiency. The most frequent critique throughout the report was that more specific data, regarding times and costs, had not been generated. The RFG hoped that later studies would be more data rich.

Gropius's Tentative Conclusions, April 1929

Gropius' own tentative conclusions regarding industrialized settlement delivery are included in a lecture he gave at an RFG conference, held in Berlin on April 17-19, 1929 and published by the RFG. In the lecture, titled "The Success of Building Management

⁹⁹³ While the general tone of the introduction, which was consistent in all four reports, is closest to Lübbert's earlier publication, as well as the general attitudes of Lüders and Gropius, the various critiques included in the body of the report are difficult to attribute to any one person.

⁹⁹⁴ A number of studies of unit variants, grouped along streets and places, show that Gropius was well aware of these issues. He had chosen instead to attempt to resolve these problems at the unit scale, hoping that he could develop a type that could work in various settlement schemes. Type II and Type IV did address many of the problems of Type I, in contrast to Behrens' work, only a few years earlier.

Organization in America”, the architect made no specific mention of Törten but instead used material, gathered on his recent trip to America, in May 1928.⁹⁹⁵ His own interest in and familiarity with the newest information technology being used in the United States, already demonstrated before his trip through his work at Törten had made him an expert on this subject in Germany. In the lecture he provided case studies of these visualization instruments and methods, utilized in two recently constructed New York high-rises, the Bank of New York Trust and the Grey Bar Building.⁹⁹⁶ (Fig. 175) He used these examples to reinforce a point that was probably already familiar to most of his audience, namely that the success of American industry was rooted in its organization, not simply its mechanization. Gropius reminded the audience that the widely published work of the “American psycho-technicians”, Taylor and Gilbreth, had already demonstrated that “the American bricklayer does not achieve a more significant daily output than the German bricklayer”, but that instead, it was the use of “more functional building organization methods” which resulted in the “cost-effectiveness” of American construction.⁹⁹⁷ This better organization had now evolved from managing the manual work of bricklaying to the more mechanized work of craning precise steel structural sections, but the basic principles and instruments had not changed significantly.

After providing these examples, Gropius concluded the lecture with a revised *instruction card* from the one he had included in *Das Neue Frankfurt* in 1926. Embracing the principles behind the critique of his settlement scheme by the RFG, he first advocated

⁹⁹⁵ Walter Gropius, "Erfolge Der Baubetriebsorganisation in Amerika," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Technische Tagung in Berlin / 15 bis 17. April 1929(April 1929).

⁹⁹⁶ Ibid., 8-9. The projects were presented through their gantt and process charts, graphic projections included in order to reveal how “America builds more cost-effectively than Europe”.

⁹⁹⁷ Ibid., 2. “...amerikanischen Psychotechniker Taylor und Gilbreth...”

settlement design following “orthogonal city planning, in order to avoid arbitrary (romanticist) traffic corridors and building lines”.⁹⁹⁸ He would continue to endorse the “typification and norming of building components”, but not entire structures, as he had done 1926, adding that the “the possibility of variability” of these components must also be considered.⁹⁹⁹ Following the model of the American *provisional city*, Gropius advocated for the “reduction of the lifespan of the building” as a means to reduce construction costs and “prevent the obsolescence of a building”.¹⁰⁰⁰ This would be accomplished through the “easing of building regulations” on “essential elements”, replacing heavier more durable materials with “lighter materials”.¹⁰⁰¹ To “increase the speed of construction”, the architect encouraged the cutting of bureaucratic red tape and improved coordination between regulating bodies.¹⁰⁰² Planned deregulation at the national and municipal scale could then be complimented by the introduction of the instruments and methods of modern industrial organization, including the “use [of] work scheduling and routing forms [instruction cards and gantt charts] and construction plant plans”, which would allow for “the closer collaboration between architect and contractor through the field office, the clearer division of responsibilities for all subcontractors, the careful preparation of work schedules, architectural and engineering drawing sets, routing plans, wage systems, and the planned education of employees working for their specialized tasks.”¹⁰⁰³ Simpler regulation and better organizational instruments and methods were the only hope for dealing with the

⁹⁹⁸ Ibid., 3.

⁹⁹⁹ Ibid.

¹⁰⁰⁰ Ibid.

¹⁰⁰¹ Ibid. Adolf Loos had advocated for a similar approach in Vienna, nearly a decade earlier, also following American examples. Eve Blau, *The Architecture of Red Vienna, 1919–1934* (Cambridge: The MIT Press, 1999). Gropius certainly knew of this project, which had been published alongside Törten in Block, *Probleme Des Bauens [Problems of Building]*.

¹⁰⁰² Gropius, "Erfolge Der Baubetriebsorganisation in Amerika."

¹⁰⁰³ Ibid.

biggest challenge to affordable housing in Germany, “reducing loan interest” expenses.¹⁰⁰⁴ The settlement scale had been advocated as the optimal unit of urbanization, in which the “massing of building in large-scale construction sites” helped one to “better manage resources and more rationally distribute cost”.¹⁰⁰⁵ Following another American example that Taylor also often discussed, he called for the “shift from unionization” of the building trades to wage systems that would more directly “reward performance and financial thoughtfulness” of individual workers.¹⁰⁰⁶ Gropius tempered his praise for the American experience by concluding that while the local building industry could “greatly benefit ... through insight of American practices”, it was imperative that one be mindful of Germany’s “different economic context” before setting out to “merely acquire or imitate successful American practice.”¹⁰⁰⁷ In the future, Gropius hoped that the RFG would define a more “organic rhythm and flow” for deriving “practical methods” through “new experiences” applying the American methods of Taylor and Gilbreth within the German context. In April 1929, Gropius could not have known that the already fragile German economy would be pushed over the edge by the stock market crash later that year, ending further experimentation and standardization work, as coordinated by the RFG, in 1930, and leading to significant political changes that would lead to his own emigration to the United States. There, the same deregulated American political economy of construction lacked the kind of initiatives that had afforded him the unique opportunity to experiment.¹⁰⁰⁸

Ernst May’s Experimental Program in Frankfurt, 1926-1930

¹⁰⁰⁴ Ibid.

¹⁰⁰⁵ Ibid.

¹⁰⁰⁶ Ibid.

¹⁰⁰⁷ Ibid.

¹⁰⁰⁸ Gilbert Herbert, *The Dream of the Factory-Made House* (Cambridge: The MIT Press, 1984). Here Gropius, working with Konrad Wachsmann, followed an ontological process more similar to that of Edison or Atterbury, developing a complex detail deductively and not through the laboratory method.

On February 27, 1928, the RFG finally signed a contract with the municipality of Frankfurt A.M., promising to subsidize nine hundred “experimental buildings” of the Frankfurt System of fabrication and *montage*, or “assembly”. This would be more than the total sum of all the other three experimental settlements combined, and was expected to contribute ten years of data production.¹⁰⁰⁹ (Fig. 176) The manager of this *laboratory*, Ernst May, had been engaged in his own experimental work since April 1926, paralleling, and often informing Gropius’ work at Dessau.¹⁰¹⁰ His work for the RFG was part of the much larger coordination of the municipality’s housing program, and was directly responsible for the delivery of more than ten thousand units of housing, between 1925 and 1932.¹⁰¹¹ May had significantly more experience in settlement-building than Gropius had had, prior to 1926.¹⁰¹² During the difficult immediate postwar period, Ludwig Landmann (1868-1945),

¹⁰⁰⁹ Wagner’s practical experiment in Berlin consisted of five hundred units. Gropius had received support of 256 experimental buildings, with 156 actually being managed and documented according to RFG requirements. May’s own documentation process, which began in April 1926, even prior to the signing of the contract with the RFG, was as detailed as the one required by the association. He had already completed 10 experimental units in the first phase of the Praunheim Siedlung, between May 1, 1926 and January 1, 1927, before staging 204 concrete panel and 41 brick experimental units, between July 1, 1927 and April 1, 1928. Praunheim’s final phase, whose planning, but not construction or occupation, was also assessed in the April 1929 report, included an additional 216 panel and 186 brick experimental houses. Phase Three was constructed between August 1, 1928 and July 1, 1928. In addition to Praunheim, the RFG also inspected the Mammolshainerstrasse Siedlung, where the Frankfurt System had first been applied to multi-unit buildings. 100 units had been settled by the time of the visit. A further 378 panel units were built at the Westhausen Siedlung, with the first phase completed in 1930, right before May left for the Soviet Union, and the second in 1931, just as the RFG was disbanded. The conclusion of this last phase of experiments would be summarized by May in a new system, for Moscow, drawn up in 1932. Between Westhausen and Praunheim’s second and third phases, a total of 808 experimental Frankfurt System units, not counting the brick variants also used in the research process, had been constructed. With Mammolsheim, and the brick units, the total approaches well over a thousand experimental units, about 10% of the total units constructed during May’s *Neue Frankfurt* housing program.

¹⁰¹⁰ May published Gropius’ initial findings. Gropius’ use of *Bimsbeton* was influenced by May’s work.

¹⁰¹¹ Scholars have differed on the total amount, but all of the figures exceed this number. The primary surveyors of May’s work in Frankfurt are Rosemarie Höpfner and Volker Fischer, ed. *Ernst May Und Das Neue Frankfurt 1925 - 1930* (Frankfurt: Deutsches Architektur Museum, 1986)., DW Dreysse, *Ernst May Housing Estates: Architectural Guide to Eight New Frankfurt Estates 1926-1930*, trans. Patricia Grossman (Frankfurt: Fricke, 1988 (1986)). and Claudia Quirling, *Ernst May: 1886-1970*. I have also referred to Suzanne Henderson’s doctoral work on May.

¹⁰¹² The Frankfurt native was one of the most trained and experienced settlement-builders of the interwar period and the only architect to have studied with both Theodor Fischer and Raymond Unwin. Between 1919

Frankfurt's mayor and May's most consistent advocate, had gained notoriety by saving one of the city's oldest municipal building societies, the *Aktienbaugesellschaft für kleine Wohnungen* (ABG)¹⁰¹³, through a combination of lobbying for an increase in the municipalities percentage of ownership and the introduction of modern management principles. In 1924, he would use this success to oust the incumbent, Mayor Voigt, who had described Frankfurt's housing shortage as "nearly insurmountable", and furthermore, to begin a similar set of initiatives, combining increased public support of municipal building societies with an application of systematic organization to their management, as well as to that of the municipality. Landmann was to May at the municipal scale, what Paul Jordan had been to Peter Behrens at the industrial plant scale, the individual who provided a systematic management foundation onto which the principles of experimental standard derivation, as well as motion study, could be overlaid. This productive relationship did not result in absolute control over housing delivery, as Landmann and May were constantly required to make concessions to the myriad of vested interest groups, often representing political extremes. However, it did give May the unique opportunity to manage experimental settlement-building at a larger scale, that of the territory, and to a finer grain, that of the building component, than had ever been attempted by a modernist architect.¹⁰¹⁴

and 1924, May had been managing a regional-scale housing delivery initiative in Silesia, before being called back to his hometown by the newly elected Mayor and DDP member, Ludwig Landmann, to head the municipal planning department, the building department, and the newly formed settlement office, as well as to serve on the board of directors for one of largest municipally-owned building societies, the ABG.

¹⁰¹³ About 1/3 of the Frankfurt Housing Program funding was directed towards two cooperative building societies, the ABG and the Mietheim A. G., during between 1926 and 1928. Ernst May, "Grundlagen Der Frankfurter Wohnungsbau-Politik," *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 7/8(July-August 1928).

¹⁰¹⁴ Martin Wagner's work in Berlin approached a comparable scale, in terms of production, but not in terms of experimentation. More units were involved in the laboratory work in Frankfurt than in Berlin.

May maintained a consistent dialogue with nearly all of the key protagonists involved in scientifically managed settlement-building in Europe during this period, including Martin Wagner, Walter Gropius and Le Corbusier.¹⁰¹⁵ In contrast to Gropius and Le Corbusier, May's discourse, design methodologies and formal language evolved more *gradually*, but they were more consistent as a result. Whereas Gropius, like Behrens, had never fully embraced what Sanford Anderson has called the *creative potential of the norm-form tension*, implicit in Hermann Muthesius' theories, and whereas Le Corbusier chose to adopt a more explicitly industrial management vocabulary to talk about his own work, May continued to use the vernacular modern discourse of *Typisierung* and *Typenbau*, finding it more than adequate to describe his experimentation and use of motion study instruments. Before turning to the analysis of May's housing program, it is worth summarizing his own theories of settlement-building.

Throughout May's writings from this period, his use of what Francesco Passanti has theorized as the *vernacular as conceptual model* to explain his own experimental work is consistent. In 1926, and again in 1929, May explained that the "dwelling" was a *Massenbedarfsartikel*, or "mass consumer article", as well as a "necessity", such as "food and clothing".¹⁰¹⁶ However, unlike those articles, the dwelling was no longer undergoing the continuous process of *Typisierung*, or "standardization", which had allowed for the

¹⁰¹⁵ Gropius' work at Törten was first published in May's journal, *Das Neue Frankfurt (DNF)*, in December 1926. He also benefited from a team of highly trained associates, many of whom had gained their experience in settlement-building from working with Adolf Loos in Vienna during the highly traumatic postwar years. May also showed an early interest in and comprehension of Le Corbusier's pioneering trials and errors in the south of France, including photographs of Pessac, alongside those of the first completed *Serienbauten* at Praunheim, in the first issue of *DNF*. Le Corbusier would return the favor in 1928, calling May's Frankfurt System a "remarkable industrial process", something that he had not yet achieved. Cited in Mary McLeod, "'Architecture or Revolution': Taylorism, Technocracy, and Social Change," *Art Journal* 43, no. 2 (1983).

¹⁰¹⁶ Ernst May, "Mechanisierung Des Wohnungsbaues," *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 2(December 1926). "Housing Policy of Frankfurt."

“efficiency and systematization” of their production, and had informed the application of mechanization.¹⁰¹⁷ Dwellings had been undergoing a process of typification “up until the middle of the 19th century”, gradually “crystalizing into certain unified forms” that were “due in part to similar habits and economic relations”, as well as “local building materials”. Instances of these diachronically developed types “repeated, with slight variations” had been the “self-evident principles of rational dwelling-generation ... abandoned by the ... individualism of the second half of the last century, to the detriment of previously harmonious city-images.”¹⁰¹⁸ It was the “architecture of these ordinary buildings”, the *bürgerlichen Bauten*, which would determine the “modern city-image”.¹⁰¹⁹ While the necessary preconditions for a “unified” architecture of the ordinary had been absent “for many decades” in Germany, a number of factors had again contributed to a “favorable situation” for a new kind of *Wohnungsbautätigkeit*, or “house building activity”, comparable to that of earlier vernacular architecture and benefitting from the principles of industrial organization, to take form.¹⁰²⁰

The prerequisite for adopting the principles already used in the “workshop or factory” required essentially the same basic processes that had existed in vernacular architecture, *Typisierung*, or standardization, and *Normung*, which May translated as “dimensional standards”, just as Lübbert had defined.¹⁰²¹ A key aspect of standardization was the act of “evolving types” through *creative building activity*. In 1929, May explained

¹⁰¹⁷ The term *Typisierung* appears in both articles referenced in the previous footnote. In the 1929 article, May himself chose to translate the term *Typisierung* as standardization, just as Le Corbusier had done, conceptually, in 1920. Pevsner would do the same in Nikolaus Pevsner, *Pioneers of Modern Design: From William Morris to Walter Gropius* (London: Pelican, 1977 [1936]).

¹⁰¹⁸ Ernst May, “Wohnungspolitik Der Stadt Frankfurt Am Main,” *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 5(April-June 1927).

¹⁰¹⁹ *Ibid.*

¹⁰²⁰ “Housing Policy of Frankfurt.” The same point, albeit less explicitly, was made in 1926-1928.

¹⁰²¹ *Ibid.*

that between 1926 and 1929, he and his team had “evolved a total of 18 types for the requirements of the population” of Frankfurt, “evolved” *Kleinstwohnung*, or “smallest dwelling” types, for the “poorest class of the population to secure shelter”.¹⁰²² (Fig. 177) The Frankfurt Kitchen was also presented as an *Entwicklung*, or “evolution”, of the older live-in-kitchen; through the coordination of the RFG, the data collected in this experimental work would then inform the Munich Kitchen, at the experimental settlement in that city.¹⁰²³ (Fig. 178) May and his team had also “evolved” *Normanblätter*, or “standard sheets”, (essentially instruction cards) describing a number of building component norms tailored to the municipality of Frankfurt rather than Germany as a whole.¹⁰²⁴ (Fig. 179, 180) In 1928, May explained that the “*Frankfurter Siedlungen*” were far from the “fulfillment of a new style”, but instead described the work as one of many “way finding markers on the path to a contemporary architectural expression of the 20th century”.¹⁰²⁵ In 1929 he reinforced this point, explaining that these evolved types were tentative standards and that

¹⁰²² Ibid.

¹⁰²³ Ibid. “Die Entwicklung der Frankfurterküche aus der Alten Wohnküche” was first published in 1926. A Munich Kitchen, informed by the experimental work in Frankfurt, was included in the experimental settlement in Munich in 1927-29.

¹⁰²⁴ Ibid. Frankfurt Norms were directly modeled on DI-Norms, but unlike those tentative standards, these were both generated and applied within the political boundaries of the municipality. This scale of standardization was unique to May’s work. Gretta Lihotzky oversaw the preparation of a number of these norms, not only the Frankfurt Kitchen, a darling of recent scholarship, but also a norm for agricultural sheds to be placed in allotment garden colonies, Lihotzky Städtisches Hochbauamt, “Frankfurter Norm Für Kleingartenbauten: Xii. Kleingartenlauben Typ. I Rechts,” (Frankfurt: DAM), as well as a norm for the allotment gardens themselves, Aufgestellt vom Stadt. Gartenwesen Frankfurt, “Gartentyp J Garten Zu Haustyp 10,” (DAM, February 1929). There was also an entire series of *Frankfurter Norm Für Kleinwohnungsbauten* (modeled on the earlier DI-Norms praised by Muthesius and Gilbreth) offering standards for door handles, window openings and window assemblies, only to name a few. Many of these were published in *DNF*. The details of May’s Frankfurt System were also issued through this format. In nearly every case, these standards were the result of laboratory work, issued only after being *conceived, constructed and settled serially*, to paraphrase Le Corbusier. May also added a Frankfurt Registry offering citizens a curated list of industrial products.

¹⁰²⁵ “Sie wissen auch, das die Formen der Frankfurter Wohnsiedlungen noch nicht die Erfüllung eines neuen Stiles bedeuten, aber auch, das ihre Arbeiten wesentlich sind als Merksteine auf dem Wege zu einer zeitgemässen baukünstlerischen Ausdrucksform des 20. Jahrhunderts.” May, “Grundlagen Der Frankfurter Wohnungsbau-Politik,” 124. May is not simply being more humble or comprising, he is following a different set of ontological theories, rooted in earlier ideas of typological evolution, which are also compatible with the laboratory method.

he and his colleagues were “aware that what we have done and are yet going to do, cannot be final and conclusive.”¹⁰²⁶ The gradual evolution of types, a concept based on pre-modern architecture and compatible with the principles of modern industry, was still applicable to the “new building” even though its ultimate “style would no longer be national or local”, as the “modern communication and means of transport” had made the world “very small”, leading to “similar principles of construction in Europe, Asia and America”.¹⁰²⁷

Nevertheless, May saw these common preconditions, as well as a potentially unified *Weltstile*, or “world style”, not as some predetermined or essential quality, but as the potential result of synchronic practices conducted simultaneously in various localities.¹⁰²⁸

May’s application of the *vernacular conceptual model* in conjunction with contemporary industrial organization encouraged him to engage local conditions with trans-local methods. This engagement was rooted in his own Unwinian town-planning training and his understanding of the principles of American industrialized settlement-building, published in Wagner’s journals, and embodied in approaches such as Conzelman’s Unit System, which May referred to as the “first experiment (in) reforming dwelling-

¹⁰²⁶ "Housing Policy of Frankfurt," 37-38.

¹⁰²⁷ Ibid.

¹⁰²⁸ Ibid. May was certainly one of the German architects who would influence the “serious American and English writers on modern architecture to conclude their essays by remarking that we are in a “period of gestation”, that we have not yet “arrived at a consistent style””, much to the chagrin of Alfred Barr, who is quoted here. Phillip Johnson and Henry Russell Hitchcock took it upon themselves to define an “International Style” following their own disciplinary training, 19th century art history and market-driven art criticism. Henry-Russell Hitchcock and Philip Johnson, *The International Style* (New York: W.W. Norton, 1996 (1932)). Gropius was almost certainly alluding to this in 1935 when he complained that “‘modern’ architecture became fashionable in several countries; with the result that formalistic imitation and snobbery distorted the fundamental truth and simplicity on which this renaissance was based.” Walter Gropius, *The New Architecture and the Bauhaus* (Cambridge: The MIT Press, 1965 (1935)). The important distinction between May’s idea of participating in the formation of a world style and MoMA’s fabrication of one is not that the former is rooted in social and technological issues while the latter’s “principal concern (are the) aesthetic qualities of the Style”, as Barr proudly boasted in 1932, but that there are two distinct ontological theories at play. I will discuss these differences in more detail in the Conclusion.

building from the ground up.”¹⁰²⁹ In his survey of earlier experiments in America and Europe before 1926, May concluded that the “lack of success, in particular with regard to economy, of all of these experiments”, had less to do with the particular materials or building methods used, and more to do with the “lack of continuity” of the experimental process, caused in part by a lack of understanding from private contractors and in part from regulatory bodies.¹⁰³⁰ A devotion to a *gradual* trial and error process is clearly visible in May’s work, particularly at Praunheim, where the settlement was designed so as to benefit more directly from three experimental phases, with each intended to inform the next. May also consistently praised the multiplicity of parallel initiatives under way at this time in “various parts of the Reich as well as in foreign countries”, offering “different means to achieve the same goal”.¹⁰³¹ The replacement of conventional building components, particularly the standard brick, could not simply be decreed, but was to instead be done “gradually, over decades”, after which “all of these experiments” could inform standards to guide “mass production”, and “reduce the cost” of housing delivery.¹⁰³² The same tone from 1926 was evident in his last text, written in 1930, prior to his move to the Soviet Union.¹⁰³³

¹⁰²⁹ May, "Mechanisierung Des Wohnungsbaues." May's entire approach in Frankfurt is very closely aligned to the principles argued for by the American engineer in his article, John E. Conzelman, "Ready-Made Houses," in *Proceedings of the Sixth National Conference on Housing: Housing Problems in America* (New York: National Housing Association 1917). May was probably exposed to the principles of scientific management during his time as the town planner of the cities of the dead, cemeteries for German soldiers during the Great War, discussed in detail in Claudia Quirling, *Ernst May: 1886-1970*.

¹⁰³⁰ May, "Mechanisierung Des Wohnungsbaues." May proved to be a much more patient *experimenter* than Le Corbusier, Gropius or Frederick Taylor.

¹⁰³¹ Ibid. In contrast, Martin Wagner often advocated a more centralized approach, as clearly demonstrated in his own diagram of how his research would inform Germany's cooperative building societies in Martin Wagner, "Das Bauhüttensystem," [The Bauhütten System.] *Soziale Bauwirtschaft* 3, no. 10/11 (20 May 1923). (Fig. 181)

¹⁰³² May, "Mechanisierung Des Wohnungsbaues."

¹⁰³³ "Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main," *Das Neue Frankfurt – Internationale Monatsschrift für die Probleme Kultureller Neugestaltung* 2/3 (February-March 1930). In this text, May praised the RFG for subsidizing his experimental program of type evolution, both through his settlements and his two experimental panel fabrication plants, the first of which was located at the Frankfurt Fair in two exhibition

While May is most known for the *rationalization of off site fabrication*, resulting in the development of the Frankfurt Panel System, his real focus was on the *rationalization of intellectual work*. Like Lübbert, May argued that one could no longer “draw up plans of every small dwelling” since such inefficiency would result in separate structural and area calculations, cost estimates, specifications, and individual architectural drawing sets from which each structure would be built.¹⁰³⁴ Seen through the lens of the vernacular conceptual model, this inefficiency was first and foremost ontological, with each project neither informed by nor informative to the overall evolving type, and further *blocking* what Muthesius called *sachlich progress*. Through the use of this theoretical lens and the more practical instruments of motion study, May heeded Muthesius’ warning as to the *temporal and geographical limits of types*, searching out local materials, such as the pumice used to improve the thermal insulation properties of his panels, as well as maintaining a municipal, rather than national, scale to his norms. Both decisions were met with criticism, both from the more rationalistic faction of the RFG, who equated rationalization with universalization, as well by its more conservative members, for whom vernacular architecture constituted a unified ideal, not a conceptual model for engaging geographical and temporal contingencies.¹⁰³⁵ For May, typification work was an active pursuit of creative building

pavilions, *Haus Offenbach* and the *Haus der Technik*, and the second, larger plant, located outdoors, in the city’s East Harbor.

¹⁰³⁴ "Housing Policy of Frankfurt."

¹⁰³⁵ The notion of standardization as being the application of already universal standards, instead of their production locally, is a common misconception, rooted in the reading of all modern architecture through the theories of a relatively small group of individuals. One example of this assumption is the discussion of May’s work in Suzanne Henderson’s dissertation, where she argues that because “(m)ost of these proposals were limited to a one-time use “ they therefore “ skirted the basic tenet of standardization.” (Page 113) Here she also uses the terms “rationalization ideology” as a “propagandistic” tool. This reading of May’s work ignores his own extensive discourse on standardization, before, during and after his experimental work in Frankfurt. A “rationalistic ideology” can be found in the writings of Hannes Meyer, in his 1928 manifesto, titled “Building”, where he claims, “all things in this world are a product of the formula”, in Ulrich Conrads, ed. *Programs and Manifestos on 20th Century Architecture* (Cambridge: The MIT Press, 1971). This attitude is

activity *limited by locational and temporal contingencies*, one that could lead to more general discoveries but one that did not begin with universalizing generalizations, whether they were aesthetic, technological or social in nature.

In 1926, building upon Unwin's earlier rationalization of the settlement into groups of interchangeable unit-parts, May, like Le Corbusier, explained that the dwelling unit constituted the elementary "cell of the city".¹⁰³⁶ In 1927, this same point was reiterated as the first "foundational theses of the new epoch of city-building", exclaiming that "first the house, then the street" should be conceived.¹⁰³⁷ To the first theses, he explained that modern "city-building" was also *Landschafts Steigerung*, or "landscape management", a new idea also rooted in the vernacular model. In practice, May's settlements were modeled, studied and presented in his journals, as large, unified, but soft-edged, landforms, similar to those presented in Unwin's manual.¹⁰³⁸ (Fig. 182, 183) To "complete the ten commandments of city-building", May essentially summarized his mentor's work, with some important modifications. As restated by May, the "road should never be an end in itself", since its "content, form and width was derived primarily from considerations for

diametrically opposite to the laboratory method, although that certainly does not mean that similar phrases cannot be extracted from Taylor's own *propagandistic* writings, or those of Le Corbusier.

¹⁰³⁶ May, "Mechanisierung Des Wohnungsbaues." "If you were to look down from the sky on the confused and intricate surface of the earth, it would be seen that human effort is identical throughout the ages and at every point. Temples, towns and houses are cells of identical aspect, and are made to the human scale. One might say that the human animal is like the bee, a constructor of geometrical cells." Le Corbusier, *Urbanisme* (1925)

¹⁰³⁷ "Wohnungspolitik Der Stadt Frankfurt Am Main." Marie Lüders would exclaim, "First the kitchen, then the façade!" in Marie- Elisabeth Luders, "Erst Die Küche - Dann Die Fassade!," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Sonderheft Nr. 2, no. Gruppe II 6, NR. 2 (June 1928).

¹⁰³⁸ May, "Wohnungspolitik Der Stadt Frankfurt Am Main." May, like Le Corbusier and Unwin, had developed his visual planning methods from John Ruskin's compositional techniques. May included panoramic views of historic Frankfurt, viewed from the Main River paired with panoramic studies of the new settlements, stretching along the Nidda River in DNF (May 1926). As the settlements like Praunheim developed, they were also documented through photographic panoramas, ranging in scale from a series of settlements to a grouping of units. (Fig. 182) May and his team also studied the color schemes of Frankfurt's vernacular buildings, using these studies to inform Praunheim, as seen in plan oblique published in 1928. (Fig. 183)

transport”.¹⁰³⁹ Urban *places* should not simply reflect the traffic corridor, in three dimensions, but rather a more “dynamic principle of motion”, built up of “cubes”.¹⁰⁴⁰ May argued that the size of residential blocks should be as large as possible, as the “larger the block, the more economical the site work”.¹⁰⁴¹ Furthermore, the basic morphological element was no longer the perimeter “housing block, closed on all sides,” but instead the new “cell of planning” of the *Hausreihe*, or “house series”.¹⁰⁴² He also argued that the “development plan” should determine the “price of land”, and not the other way around.¹⁰⁴³ Exhibiting a comfort in discussing the organizational alongside the aesthetic, typical of Unwin and here attributed to Theodor Fischer, which was uncommon in Germany in the late twenties, May stated that “(i)f a plan looks good (not only in the Fine Arts sense) it probably is good”.¹⁰⁴⁴

May explained that the *einzelne Haus*, or “the individual house”, grouped into a *Hausreihe*, or “house series”, arranged around a “block”, “fitting organically together” into a “*Stadviertel*”, or “urban neighborhood”, as part of *Siedlung*, such as Praunheim, and finally, combined into the particular Quartiers, or “urban quarters”, like the Nidderad Valley, were the basic blocks of a *gestalte Masse*, or “shaped mass”, and *Bodenplanwirtschaft*, or

¹⁰³⁹ Ibid. In both American and English landscape architecture, which dominated town-planning in those two countries, as well as the German irregular schools of city-building, the manipulation of the roadway was the primary instrument of site design and visual planning, creating problems at the unit scale, whereas regulation- or engineering- planning, proposed building masses that simply followed the line of traffic.

¹⁰⁴⁰ Ibid.

¹⁰⁴¹ Ibid.

¹⁰⁴² Ibid. A *Hausreihe* was essentially a modern *slab*.

¹⁰⁴³ Ibid. Here, May is referencing the municipal *Enteignung*, or “expropriation”, powers that he used to purchase primarily agricultural land at rates that were lower than asking price but higher than the tax estimate. For example the average asking price, per square meter, on Frankfurt’s periphery was 15 RM, the assessed price was 2.5 RM, with the municipality paying the owner 3.5 RM for the property. “Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main,” 32.

¹⁰⁴⁴ “Wohnungspolitik Der Stadt Frankfurt Am Main.”

“economical land use”, managed together strategically through a “general plan”.¹⁰⁴⁵ This mass also indexed the process of experimentation and standardization by presenting variants of a type in a formal dialogue with some of the preconditions that informed this massing, providing a “sweeping overview” of the *Wohnungsbautätigkeit*, or “housing delivery activity”, to the viewer.¹⁰⁴⁶

The general plan of the city, both in terms of spatial and economic organization, was further described by May in terms of a gradual evolution and adaptation. Similar to the actual practice of the garden city movement, May and Landmann’s settlement policy focused less on escaping the city or establishing fully self-sufficient communities and more on using these developments to gradually lower the cost of land in the city center. To accomplish this broader strategy, settlements required the construction of units, which would appeal to a variety of constituencies, as well as good transportation links, shops, schools, and cultural and religious institutions, all of which were planned within the settlements. In the process of fostering the *Kernstadt*, or “urban kernel”, from which these settlements sprouted, the *Zentralstadt* would evolve.¹⁰⁴⁷ Once the city could afford to purchase land and rehabilitate the existing fabric, the *Zentralstadt* would retain some housing, gain new affordable housing, and would continue to offer certain programs, such

¹⁰⁴⁵ Ibid. In 1928 May had explained that the “fulfillment of architectural aesthetic is no longer seen in the composition of a beautiful facade with the symmetrical layout and ... pillars, cornices and ornaments” but “through serial stringing of similar elements, through harmonious incorporation of the buildings into the landscape architectural and urban effects experienced through time.” The standardized unit was now the order of the settlement. “Grundlagen Der Frankfurter Wohnungsbau-Politik.”

¹⁰⁴⁶ “Housing Policy of Frankfurt.” The process of experimentation and standardization had replaced the local building traditions that Unwin had initially counted on for providing *individuality* to a town plan but he had found that modernization had rendered them useless in assisting in this endeavor. While Unwin’s town planning continued to offer modern architects the means of systematically managing the site design, social organization and visual planning of settlement, it was now the laboratory method that generated individuality while pursuing the more general, in addition to other factors, such as geology and solar orientation.

¹⁰⁴⁷ “Grundlagen Der Frankfurter Wohnungsbau-Politik.” Also discussed in the 1929 speech.

as universities, corporate headquarters, large banks and theatres.¹⁰⁴⁸ The “colonists”, as May often called the occupants of his twenty settlements, and the citizens of the old town, would meet within the green belts between the city and the new compact towns, through the more collective amenities of sports fields and playgrounds, as well as through the newly established *Kleingarten* colonies, offering the same self-sufficiency, recreation and potential economic benefits to both the colonists living in the multi-unit housing and the residents of the old town. It was within this in-between space, that May imagined a constructive and vernacular dialogue between these various constituencies regarding the future of *Wohnkultur*.

Throughout the late twenties, May was clear that he was not critiquing the old city center, but was instead focused on the recent wave of tenement housing inserted there, during his own childhood, as well as the “concentric” low-density suburban sprawl that had expanded into the rural areas around Frankfurt.¹⁰⁴⁹ The new “colonies” sought to provide larger units than the late 19th century tenements, higher density than the recent concentric suburbs and some sense of place as could be found in the old city. The model for the colony was the *Kleinstadt*, or “small town”, not the suburb, an urban unit that would be “equipped with all the facilities needed for everyday life”, and well linked to other programs and places of work.¹⁰⁵⁰ As the transportation network improved, the center-city *kernel* would seed more “daughter towns” towards the direction of Wiesbaden, to the west, Hanau to the

¹⁰⁴⁸ Ibid.

¹⁰⁴⁹ Ibid.

¹⁰⁵⁰ Ibid. Also discussed in "Housing Policy of Frankfurt."

north, Darmstadt to the south and Nauheim to the east, all the while maintaining rural land and the individuality of existing towns.¹⁰⁵¹

The long term gradual planning of the center city, directed strategically by a general plan and supported by key infrastructure, but open to participation from the heterogeneous mix of agents that were involved in housing delivery during the Weimar period, was also detectible in the design of the units themselves. In particular, May explicitly designed the *evolved Kleinstwohnungen* to initially serve as “emergency dwellings” for the poorest residents of Frankfurt, but planned for these units to be combined over time, through the residents’ own initiative, into larger units.¹⁰⁵² Long term planning, through infrastructure and economic policy, more than increased centralization or municipilization of housing delivery, was central to May and Landmann’s *real Politik*.¹⁰⁵³ (Fig. 184) For both, the principles of systematic and scientific management, already in use in the factory, revealed key interdependencies between processes, allowing one to “obtain maximum output with a minimum effort”, in terms of capital, resources and labor.¹⁰⁵⁴ May’s “social economy” was primarily defined by considerations for the “economy in the long run”, not only the “economy of today”, particularly as related to necessary services, such as transportation infrastructure.¹⁰⁵⁵ To consider the “health of the people” of Frankfurt, this “social economy” had to use the same *Wirtschaftlichkeitsberechnungen*, or “economic

¹⁰⁵¹ "Housing Policy of Frankfurt," 9.

¹⁰⁵²Ibid. At Mammolsheimerstrasse (1927-28), the first emergency dwelling settlement, the units were designed only to serve the current emergency housing needs; they have since been demolished. At Westhausen (1929-1931), May designed extremely small units with the possibility to be combined, which is exactly what happened over the subsequent decades.

¹⁰⁵³ May shared the view of the centrist politicians that home ownership provided a valuable economic and social infrastructure to new settlements. By providing these more affordable units on the periphery, through better settlement planning, more efficient fabrication and construction, as well as through subsidies, May and Landmann hoped to bring down the cost of housing in the city center. "Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main," 24.

¹⁰⁵⁴ "Grundlagen Der Frankfurter Wohnungsbau-Politik."

¹⁰⁵⁵ Ibid.

efficiency calculation”, instruments and methods that had benefited private industrial plants, under the “economics of the old school”¹⁰⁵⁶; however, this calculation would be more difficult to solve given the competing interests of the city’s lobby groups, all of whom had a say in Frankfurt’s housing program during this period.

Frankfurt’s Housing Program, 1925

General consensus as to the dire shortage of housing in Frankfurt, initially caused by the rapid industrialization before the Great War and then exacerbated in the immediate postwar period, could be found among most of the political parties.¹⁰⁵⁷ This consensus contributed to Ludwig Landmann’s election as Mayor in 1924, as he promised to address this issue through experience gained in reforming Frankfurt’s largest municipally owned building society. In the first of a series of debates surrounding this issue, held in February 1924, it was agreed upon by politicians, from both the far Left and Right, that some action was required.¹⁰⁵⁸ A year later, 14,353 applications for affordable housing were registered by the municipality, of which half were classified as “emergency cases”, where the lack of housing was of concern to the citizen’s health.¹⁰⁵⁹ By March, a general consensus was reached that 10,000 units of subsidized housing should be delivered over the next decade.

¹⁰⁵⁶ Ibid.

¹⁰⁵⁷ An excellent history of the politics in Frankfurt at the time, specifically as they related to housing program, is included in Dietrich Andernacht and Gerd Kuhn, “Frankfurter Fordismus,” in *Ernst May Und Das Neue Frankfurt 1925 - 1930* ed. Rosemarie Höpfner and Volker Fischer (Frankfurt: Deutsches Architektur Museum, 1986).

¹⁰⁵⁸ Ibid. The major political parties in Frankfurt, from Left to Right, who agreed on the need for a more concerted housing program included the KPD, the SPD, Zentrum, Landmann’s DDP, the DVP and the DNVP, but the KPD and the DNVP did not all fully support the final version of the program. The *Deutsche Volkspartei* (DVP), is sometimes referred to as a conservative liberal party. The *Deutschnationale Volkspartei* DNVP or the German National People’s Party was a conservative party. The *Unabhängige Sozialdemokratische Partei Deutschlands* (USPD) was a leftist party that sat politically between the SPD and KPD. As Andernacht and Kuhn have argued, Frankfurt during this period was a complex political entity; the simple labels “socialist” or even “social-democratic” to its housing program, as a number of scholars had done then and continue to do, do not apply, in contrast to cities like Berlin or Vienna, whose housing programs were the direct result of a more outright SPD majority.

¹⁰⁵⁹ Ibid.

By the fall of 1925, the Council had voted through such a program, by which time May would hold a number of positions, including Municipal Council member (with no Party affiliation), and head of the newly appointed Settlement office and the Municipal Building Department. Support came from the SPD, the single largest political party, but victory was ensured by a set of centrist parties without whom the social democrats would not be able to govern, including Landmann's DDP, the *Zentrum* or "Center" Party, a progressive Catholic party whose constituency included most of the city's skilled craftsmen, the core coalition, as well as the DVP, a right of center party that initially supported the program.¹⁰⁶⁰ Parties on both extremes of the political spectrum, including the DNVP and the National Socialists on the Right, the Communist KPD and USPD on the Left of the ruling coalition, as well as the libertarian *Wirtschaftspartei*, all voted against the program. From the start, the DDP, the Center Party and the DVP were the most consistent supporters of May and Landmann's satellite settlements program, including the powers of expropriation required to secure the rural farmland, as well as the settlement's primary housing type, the dense, small row house units and allotment gardens, which would eventually be owned by those "colonists", through the assistance of the National Homesteads program. Of the three strongest supporters of May's settlements, only the DVP actively supported the architect's experiments in the replacement of brick with prefabricated concrete panels. DVP Councilor Lion had defended the Frankfurt System as an expertise that might give "the local building industry" an advantage in competition at the national level, just as the Werkbund had

¹⁰⁶⁰ Ibid.

argued that modern design would do for the German economy at the global scale.¹⁰⁶¹

Throughout the process, pressure from the SPD to produce more low-skilled jobs handicapped the panel production process by preventing the application of mechanization, through the use of stamping machines, a modification that would have certainly lowered the overall cost of the system significantly, achieving the SPD's other ambition, lower cost housing. The interests of other political parties would also align with various aspects of the housing program and May's experimental work. For example, the contracting of a private construction company, paid for with RFG funds, to operate the fabrication of panels after 1928 appeased the DDP and DVP, who saw the funding of municipal firms with municipal money as unfair to private enterprise; the decision to apply stucco to the panels, on site, appealed to the Center Party, whose constituency consisted of skilled laborers; the adaptation of row-house units to duplexes at Westhausen, to be rented not owned, appealed to the SPD and even the KPD. Throughout this period May endeavored to balance his own personal sense of social responsibility and his interest in experimentation with his obligations to these varied constituencies and limitations as a public servant.¹⁰⁶²

Ernst May's Experimental Program, 1926-1930

Ernst May's own experimental work began during the Spring of 1926, following the shifting parameters of the municipal council's housing program, coordinated by a flexible general plan and tracked by the extensive use of standard data collection instruments in

¹⁰⁶¹ Ibid. By 1928, the DVP's internal shift further right led to a withdrawal of the system, in part for ideological and in part for political reasons; without the financial and political support of the RFG, May would have had to abandon this work.

¹⁰⁶² In terms of both financial and political support, the RFG, starting in early 1928 and ending in 1931, would prove crucial, as this national program provided May some ability to transcend more local contentions. This role is clearly discernable throughout the report, "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)," *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen* Sonderheft Nr. 4, no. Gruppe IV, NR. 1 (April 1929). The interest of each of the parties represented in municipal council is outlined in detail in "'Frankfurter Fordismus'."

the form of gantt charts and instruction cards, which documented work at all of the New Frankfurt settlements.¹⁰⁶³ (Fig. 185) While the *Praunheim Siedlung* would be designated as the primary *Versuchssiedlung*, the experimental program extended to two other settlements, *Mammolsheinerstrasse* (1927-28), a small “emergency housing” settlement near the Frankfurt Fair, and *Westhausen Siedlung* (1929-1931), May’s last settlement in Frankfurt.¹⁰⁶⁴ (Fig. 186, 187) The first two phases of Praunheim were one of five settlements, whose planning and construction began in 1926.¹⁰⁶⁵ Between April and October of 1926, May concurrently undertook the planning and construction of these five settlements, using systematic management methods and instruments applied to more conventional building materials, as well as the process of experimentally deriving his standard method of prefabricated housing delivery, through ten *Versuchbauten*, or

¹⁰⁶³ The first instruction cards and gantt charts were dated April 1926. They came in four temporal scales, documenting yearly, monthly, weekly and daily work, with 185 different types of forms in all. Wagner’s journals as well as Ludwig Landmann’s earlier work in reforming Frankfurt’s building societies ensured that modern management practice was already common, making experimentation and standardization practice much easier to conduct. Whereas Gropius was asked to add a number of these instruments after the 1928 contract was signed between the RFG and Dessau, the April 1929 report on Frankfurt demonstrated May’s greater level of preparedness, starting as early as 1926. "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)."

¹⁰⁶⁴ The RFG included data from Praunheim and Mammolsheim in their report, *ibid.* May and the RFG also utilized unit-scale experiments constructed in Frankfurt and in Stuttgart to generate experimental data, both of which were also referenced in the report. The RFG funding was also used to support work at Westhausen, but by its completion in 1931, the RFG no longer existed. May published his experimental work in *DNF*.

¹⁰⁶⁵ Three settlements were located north of the center, two to the east and one to south-west. All of these settlements were located within the recently expanded city limits, but outside of the consolidated fabric of the old city, connected to it by existing or planned tram and bus routes. Many were located near existing small towns, after which they were usually named, and next to one of the planned green no-build zones, usually on expropriated rural land. The settlements closest to the city center included more multi-unit buildings, while those located farther away, on cheaper land, including Phase I of Praunheim, consisted of a majority of row-house units, with multi-unit structures interspersed. Praunheim was the largest of this group, paired with another, settlement, Hedderheim (renamed Rommerstadt in 1928), as an urban unit, following the Nidda River valley. Praunheim’s Phase I and Phase II had a total of 2,764 units, in 1928, while Rommerstadt had 1,200 units, of which 1,182 were completed by 1928. Ginneheimer Hang, next to Ginneheim Village (where the May’s lived, later renamed Hohenblick) included 100 units, completed 1928, Riederwald, included 490 planned units, 313 of which were completed in 1928, Bornheimer Hang, had 828 units constructed in the first phase, and 1,540 units total, completed 1930, and Niederrad had 650 planned units, of which 654 were completed in 1927, including the famous Zik-Zak Block.

“experimental buildings”, constructed as part of Praunheim, Phase I, between October 1926 and January 1927.¹⁰⁶⁶ (Fig. 188)

May chose the row house as the typological site of his own experiments in industrialized building, starting with Praunheim.¹⁰⁶⁷ For his floor and ceiling construction, he adopted an already standardized building component, the Visintini System of prefabricated reinforced concrete beams.¹⁰⁶⁸ (Fig. 189) After studying a number of the systems published by Wagner, including the Atterbury and Unit Systems, May developed a variation on their two approaches, a three-meter wide, one hundred and ten centimeter tall, and twenty-centimeter deep load bearing concrete panel.¹⁰⁶⁹ The panel was cast from a concrete mix rich in pumice dust, plentiful in the region around Frankfurt, providing the panel superior insulation performance over regular concrete. While the height remained constant, with one panel providing the parapet height and a second module set to the height of a standard window, the width of the panels could vary significantly.¹⁰⁷⁰ (Fig. 190) The simple panel needed a single flat finished surface, simple forms, of wood or steel, as well as a mechanical or manual stamping machine to be cast.¹⁰⁷¹ (Fig. 191) The panels, which were all load bearing, varied from fifteen centimeters for the interior walls, to

¹⁰⁶⁶ Published in December 1926 and more extensively in May, "Wohnungspolitik Der Stadt Frankfurt Am Main.", and in Block, *Probleme Des Bauens [Problems of Building]*.

¹⁰⁶⁷ Much of the municipal council and Lübbert himself saw the row house as an optimal compromise between the single family home and the multi-unit apartment block. English domestic architecture, as well as American industrialized settlement building, particularly the work of John Conzelman, had shown that this type could be aggregated at significant densities.

¹⁰⁶⁸ The Visintini System had first been developed in Austria in 1903, and saw wide use in factory construction, in Europe and North America, by 1907. An example of this system was included in Sanford E. Thompson, *Reinforced Concrete in Factory Construction* (New York: The Atlas Portland Cement Company, 1907). It had not been used widely in residential construction. May included a discussion of the system in May, "Mechanisierung Des Wohnungsbaues."

¹⁰⁶⁹ May's system was more similar in its panel size to the first variant of Atterbury's system, used in the first Sewaren House, in 1909. He drew on the Unit System's interlocking logic, as well as the greater simplicity of its fabrication techniques, as opposed to the complex steel molds specified by Atterbury.

¹⁰⁷⁰ May, "Mechanisierung Des Wohnungsbaues."

¹⁰⁷¹ Ibid.

twenty for the exterior (as well as one interior wall) and thirty for the walls, which constituted the prefabricated foundation. They required no significant reinforcing, other than small elements to assist in transport both within the fabrication facility, as well as to and through the construction site.¹⁰⁷² (Fig. 192) The precast concrete panels were designed to interlock over the alternating courses of each of the levels.¹⁰⁷³ (Fig. 193, 194) The most complex component, in terms of fabrication, was the lintel element, which received reinforcing to span over the window and door openings and was cast with an indentation so as to receive the standard Visintini beams. The beams would span from the front of the outside street wall to the back of the outside garden wall, a span of approximately eight meters, with a maximum clear span of about five meters.¹⁰⁷⁴ The twenty centimeter wide Visintini beams also constituted the full floor or ceiling surface, which could then be finished as needed.

By early June 1926, May began experimenting with the system, constructing a full-scale model, in Frankfurt, to test the fabrication and assembly process, as well as the structural stability of the hybrid system.¹⁰⁷⁵ (Fig. 195) It included a basement, 240 centimeters in height, and three levels, each 280 centimeters in height.¹⁰⁷⁶ The panels were assembled with the assistance of a light crane, and required minimal centering. The mortar used also included the same pumice dust, which ensured a proper thermal enclosure.

Concurrently, May sent the concrete recipe for the panels to a laboratory in Munich in

¹⁰⁷² Ibid.

¹⁰⁷³ "Bericht Über Die Versuchssiedlung in Munchen [Report of the Experimental Settlement in Munich]."

¹⁰⁷⁴ Le Corbusier used the same dimension in his work at Bordeaux.

¹⁰⁷⁵ "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)."

¹⁰⁷⁶ Mammolshein was also three levels. The remaining row houses at Praunheim and Westhausen were two levels, with floor to ceiling dimensions of 285 centimeters. In one of the two Praunheim Phase II types, Type V, May experimented with split levels, with the living space pushing down into the basement 36 centimeters, itself a full 280 centimeters, and resulting in a height of 320 centimeters, allowing more indirect light into the living space, as well as a common level with the allotment garden to the north.

order to test their thermal and hydrological insulation performance.¹⁰⁷⁷ In terms of basic structural solidity, the June 1926 experiment and the three story structures, both in May's own tests and in an independent verification conducted by the RFG, were found to be sound. The speed and cost of construction, as well as the thermal and hydrological insulation, were all factors that would continue to be developed, during the later phases of Praunheim.

Praunheim Phase I

While certainly not a closed system, the Frankfurt System was specifically developed for use in row-house construction, a factor that is visible in the first ten experimental units, designed between July and September 1926 and constructed between October 1926 and January 1927 at Praunheim.¹⁰⁷⁸ (Fig. 196, 197) The row houses were organized in pairs, specifically responding to the street and an allotment garden side.¹⁰⁷⁹ (Fig. 198) The inclusion of the famed "Frankfurt Kitchen" can also be traced directly to the same source, and is reflective of Unwin's placement of an enclosed "scullery" between the large living room and the allotment garden in his work.¹⁰⁸⁰ In this early unit, the

¹⁰⁷⁷ *Bautechnischen Laboratorium of the Technischen Hochschule München*, where May had studied before the Great War. "Bericht Über Die Versuchssiedlung in Munchen [Report of the Experimental Settlement in Munich]."

¹⁰⁷⁸ May, "Mechanisierung Des Wohnungsbaues." These drawings are in turn based on a series of more detailed studies, prepared from September 16-25, 1926, by Ernst May and Eugen Kaufmann. A ground plan, Kaufmann Städtisches Hochbauamt, "Siedlung Praunheim 4: Schnitt Plattenhaus," (Frankfurt: DAM, September 18, 1926)., and a section, "Siedlung Praunheim 7: Obergeschoss Schicht li Platenhaus," (Frankfurt: DAM, September 25, 1926)., show how the assembly of the panels was studied in these experimental units. May also discussed the use of a physical model.

¹⁰⁷⁹ May, "Mechanisierung Des Wohnungsbaues." Discussed briefly in the April 1929 report.

¹⁰⁸⁰ The so-called Frankfurt Kitchen was directly influenced by English "scullery" kitchens, which appeared in "small houses" throughout the later 19th century. Similar layouts appear in Norman Shaw's concrete cottages in 1878. Ernest Newton Norman Shaw, *Sketches for Cottages, Country Residences, and Other Buildings: Designed to Be Constructed in the Patent Cement Slab System of W. Lascelles* (London: B T Batsford, 1878). Similar layouts were also included in Unwin, *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*, 326. (Fig. 199) As with the American concrete systems, here May, like Le Corbusier, had chosen an already *established* standard, common in England but not new to Germany, as a departure point for typological evolution and adaptation through experimentation and standardization within the context of

experimental panel system and the kitchen layout led to an awkwardly placed and spaced room, identical in size to the kitchen, which would be addressed in the subsequent iteration of the series. The living room received a single triple pane window, identical to the master bedroom above, while the kitchen and one of the smaller bedrooms on the top level received identical two-pane windows. Two smaller windows above the toilet and another room, on the second level, were cast into the panels themselves. By having the panels continue past the façade, they simultaneously defined a threshold between the unit and street and formed a wall, which served to support an upper level balcony that was accessed from the second of the two units. The corner units of the row had slight modifications as to the placement of the windows, defining the termination of the composition and reinforcing May's concept that the "house series", or *slab*, was the new unit of modern city building.¹⁰⁸¹ Through subsequent evolutions of the type, the window pattern would become more dynamic, using a smaller variety of window types to express the tectonic logics of the panel assembly and to relate the internal organization to the façade. While these first experimental units were finished in stucco, on site, May still hoped to either optimize the concrete panels themselves, so as not to require this additional work, or to move this work to the site of fabrication itself.

From October 1926 until October 1928, the panels and Visintini beams would be fabricated at the Frankfurt Fair in the *Haus der Technik*, a large exhibition hall equipped

Frankfurt. When the Gilbreths published their own study of "fatigue elimination in hair combing", in 1922, they also made no claims that they had invented a new type of bedroom, but rather that their own techniques of motion study could be used to analyze and transform its use. F B Gilbreth, "Process Charts: First Steps in Finding the One Best Way to Do Work (Lecture, December 1921)," *The American Society of Mechanical Engineers* (March 1, 1922). This is where May and the Gilbreths significantly differed from Alexander Klein.¹⁰⁸¹ The studies for these ten units draw on Le Corbusier's unrealized proposals for Sectors A and B. Le Corbusier, "2000 Untitled " (Paris: FLC, Undated (1926)). (Fig. 200) The shared underlying system of interchangeable parts, Unwin's town-planning, made such exchanges between *laboratories* easy.

with a gantry crane.¹⁰⁸² (Fig. 201) From the outset, various members of the municipal council criticized these efforts as either a threat to skilled labor, utilizing industrialized off-site production instead, or the number of employed unskilled laborers in the facility itself, which might be replaced by further mechanization, particularly through the use of stamping machines. In his own defense, May repeatedly reminded the individual lobbyists that the “rights” of their constituencies came at the expense of those looking for affordable housing and reflected an “irrational” use of public funds.¹⁰⁸³ In October 1926, Councilor Lion of the DVP lent his support to May’s efforts, explaining that the “experiment in the manufacturing of *Kleinhausbauten* using panelized construction” was a worthwhile investment of public funds because it not only had the potential to reduce costs, but the use of cutting edge methods would give the private and cooperatively owned construction industries of those cities a competitive edge over other parts of Germany.¹⁰⁸⁴ For the time being, the municipally owned facility was operated by the *Preußisch-Hessische Bau- und Finanzgesellschaft*, a GmbH, a significant part of whose shares were owned by the municipality.¹⁰⁸⁵

Mammolsheinerstrasse Siedlung

Between the completion of Praunheim Phase I, in early January 1927, and the start of Phase II, in late February 1928, when the contract with the RFG was finally signed, May

¹⁰⁸² May, "Mechanisierung Des Wohnungsbaues." "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)."

¹⁰⁸³ Kuhn, "'Frankfurter Fordismus'." May’s arguments were similar to those of Frederick Taylor who had argued in *Principles* (1911) that “(t)he rights of the people (consumers) are therefore greater than those of either employer or employee.”

¹⁰⁸⁴ Ibid.

¹⁰⁸⁵ Ibid. When May finally received funding from the RFG, he decided to abandon this facility for a site in the city’s East Harbor, where a private construction company would conduct operations. There, the RFG, and not the municipality, was the intended beneficiary of May’s experimentation and standardization efforts. Discussed later in this chapter.

continued the development of the Frankfurt System through the conception, construction and settlement of two hundred units at *Mammolsheimerstrasse Siedlung* (1927-28).¹⁰⁸⁶ (Fig. 203) Adjacent to the Frankfurt fair, as well as May's fabrication facility, this project would be the first "emergency housing" project and was intended to house Frankfurt's poorest residents.¹⁰⁸⁷ Planned primarily as a single housing block of three hundred units, it was organized in a campus of repetitive multi-unit slabs, including two-level slabs with sixteen units and three level slabs with twenty-four units each. Four 32-meter square units, less than half the size of the smallest row houses, shared toilets and access to a stair core. A common kitchen and laundry facilities, as well as large central plaza, completed the sparse ensemble. Mammolsheim offered May and his team an opportunity to further experiment with and standardize settlement-building at an intermediary scale between the single house-row and the settlement, informing the more closely monitored work at Praunheim in 1928.¹⁰⁸⁸ (Fig. 204) Here, May also experimented with applying stucco to the panels off site, during the fabrication process, in order to reduce the cost of labor and increase the legibility of the tectonic logic of the system on site, through the now visible mortar joints.¹⁰⁸⁹ (Fig. 205) However, later post-occupancy studies, conducted in early 1928, immediately before the start of work of Praunheim Phase II, showed that this had resulted

¹⁰⁸⁶ May, "Grundlagen Der Frankfurter Wohnungsbau-Politik," 150-52. "Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main," 43-44.

¹⁰⁸⁷ A "model house" appeared at another of the RFG subsidized settlements, the *Weißenhofsiedlung* in Stuttgart, as part of the Werkbund's "Die Wohnung" exhibition. (Fig. 202) Post occupancy studies of aspects of this unit, particularly its Frankfurt Kitchen, were conducted by the RFG there and included in the April 1929 report.

¹⁰⁸⁸ May, "Grundlagen Der Frankfurter Wohnungsbau-Politik," 122.

¹⁰⁸⁹ "Siedlung Mammolshainerstrasse," *ibid.*: 151. "In a recently completed settlement the exterior plaster was applied to the panels in the factory so that they would only need to be grouted and (so that they would) still [show] the constructive logic in a clear manner in the finished building." Block, *Probleme Des Bauens [Problems of Building]*, 195.

in a less effective environmental enclosure, leading May to specify the application of stucco finishing on-site by skilled laborers, for all of the subsequent *Panelbauten*.¹⁰⁹⁰

Praunheim Phase II

In February 1928, with the contract between the RFG and municipality finalized, May returned to the “experimental settlement” at Praunheim.¹⁰⁹¹ In Phase II, May shifted from the scale of the single *Hausreihe* grouping to that of a series of *Housereihen* grouped along two east-west streets.¹⁰⁹² (Fig. 207) In the earlier experiment, the preconditions included a flat site next to an existing rural *Hof*. The position of the slab within the overall settlement scheme allowed for an optimal solar orientation, providing the unit’s large living space light from the south. In this phase of experimental work, site design, visual planning, social organization and tectonic logic all came into play at a range of scales during a key moment of evolution in May’s system.¹⁰⁹³

The earliest version of the Phase II settlement scheme was prepared during the spring of 1927. (Fig. 208) Here, May had crafted his own fabric in dialogue with the old village of Praunheim, to the east of the site, and the *Hof*, in what was still the settlement’s geographic center. The rich variety of groupings responded to various site conditions,

¹⁰⁹⁰ "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)."

¹⁰⁹¹ By May 1927, the Praunheim Phase II panel house types were already designed, with cost estimates prepared by June 02. A gantt chart, included in the RFG report, shows that construction was planned to start in August and end in November 1927. Ibid., 94. (Fig. 206) It shows four rough construction steps and nine subsequent steps, including “stucco work”, on site, as well as the construction of infrastructure, after the completion of the units, showing that the decision to apply stucco in the factory at Mammolshein was experimental. Most of the Phase II units were constructed between February and June 1928, overlapping with the completion of Mammolshein.

¹⁰⁹² Ibid. Praunheim Phase II was the experimental work most closely documented by May and most thoroughly analyzed by the RFG. Phase II was broken up into two zones, with the zone east of Phase I, continuing to utilize the same basic unit types and construction materials and methods (standard brick), while the eastern zone included two experimental street groupings constructed using the panel system, a row of units, to the north, constructed using standard brick but following the same unit organization as the panel houses, and a third street of row-houses, to the south, which followed the same unit types and construction systems as Phase I.

¹⁰⁹³ It was this work that would be most extensively documented and analyzed by the RFG.

particularly the southerly slope towards the Nidda River, in which the act of forming street and place spaces was informed by concerns for enclosedness, vistas, as well as the internal logics of the units, as was clearly delineated in the plan. Unwin's system of interchangeable units, loosely but precisely, linked with a macro strategy of places and traffic routes, allowed May to easily adjust the overall scheme and the individual plots, while still maintaining his overall ambitions. That same flexibility would be used again a year later, in preparation for the 204 experimental panel houses. May chose to focus the experimental work on two east-west streets set between the larger existing east-west road to the north, Heerstrasse, and his newly formed road to the south, Damaschke-Anger, which turned into Am Ebelfeld to the south, where he continued to group the same two unit types he had used in earlier work to the east. Already in 1927, the two future experimental streets, Olbrichstrasse, to the north, and Putzerstrasse, to the south, followed the classic Unwinian organizational schema. By February 1928, May made only slight modifications to the scheme, placing a communal laundromat at the terminus of an existing pedestrian path, in place of six conventional row-house units; here collective programming followed visual planning. He also added a path, allowing pedestrian, but not automotive, access from the place at the western end of Olbrichstrasse to Heerstrasse.

For this phase, the settlement design plan also served May as a construction plant plan. In Phase I, the buildings were constructed before much of the public infrastructure and roadways, but in Phase II, at least partially because of the long delay in the receipt of RFG funds, "all the municipal supply lines (rainwater, wastewater, sewer, gas, potable water and electricity)", as well as the "access roads within the settlement were provided at

the start of construction to ensure the smooth transport of the construction materials".¹⁰⁹⁴ (Fig. 209) Temporary tower crane tracks simply followed the street line itself, while the future T-junctions and places at the western end of the street served to temporarily store materials and equipment, while allowing them to turn around, after delivering panels, as needed, to each of the building sites directly from the Frankfurt Fair.¹⁰⁹⁵ The same transportation infrastructure served to industrialize the preparation of the allotment gardens, and the same trucks and roads allowed for the delivery of manure to each unit, prior to *colonization*. However, motion studies and cost data collected by the RFG would show that this experiment in converting the future settlement infrastructure into a construction plant was not necessarily more economical, as "the great advantages achieved from the prior installation" of municipal services was undermined by the significant damage caused by the offloading of the panels and movement of the tower cranes¹⁰⁹⁶; as usual, the laboratory method was a costly endeavor.¹⁰⁹⁷ The conception, construction and colonizing of Phase II at Praunheim would not only generate the richest data set for the RFG, but it would directly inform Phase III and Westhausen, both of which began in 1929.¹⁰⁹⁸ (Fig. 210)

Throughout this process, May paralleled his experimental work, conducted through the "fabrication of 200 experimental units" at Praunheim Phase I, with work conducted at

¹⁰⁹⁴ "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)," 12.

¹⁰⁹⁵ Ibid. Unlike Gropius' earlier construction plant plans and the construction plant plan for Praunheim Phase III, the settlement design scheme proved adequate to also manage the assembly process, partly a result of the significant work done off-site, the settlement design itself and the organizational logic of the units assembly.

¹⁰⁹⁶ Ibid.

¹⁰⁹⁷ Ibid.

¹⁰⁹⁸ "Siedlung Praunheim," *Das Neue Frankfurt: Monatsschrift für die Fragen der Grosstadt-Gestaltung* 7/8(July-August 1928). "Siedlung Praunheim," *Das Neue Frankfurt – Internationale Monatsschrift für die Probleme Kultureller Neugestaltung* 2/3(February-March, 1930).

Mammolsheim, through the assistance of a number of projection instruments, including more conventional architectural drawings, at the unit and settlement scales, as well as physical models and management instruments. In 1926, he had described the use of a scale model, "built up ... from small wooden elements in the manner of a child's toy", to "design the panel structure".¹⁰⁹⁹ He insisted that the buildings had "not been drawn first", but had "only been transferred to paper" after these studies, "reveal(ed) a finished building (of) absolute clarity and agreement between plan and construction" organization, a technique that he would also later apply in the Soviet Union, where the kind of modeling in real-time he was doing in Frankfurt would no longer be possible.¹¹⁰⁰ This model was also complimented by a series of instruction cards studies of the sequence, duration and relative cost of brick and panel construction, which evolved from 1926 until 1930, tracking the laboratory work.¹¹⁰¹ (Fig. 211) These physical models of motion study, in conjunction with instruction cards, at the unit scale, and construction plant plans, at the group and settlement scale, assisted May in managing the more complex experimentation and standardization work, at full scale, during the fabrication of two hundred additional units at Praunheim Phase II.

¹⁰⁹⁹ May, "Mechanisierung Des Wohnungsbaues." Here the toy May is referring to is probably a set of Froebel blocks. A similar model to the one discussed here would be used by May and the May Brigade in 1932 to develop a national standard for industrialized housing delivery in the Soviet Union. Photos of this model are included in May Brigade Johan Niegeman, "Plattenbau, Typ A," (Rotterdam: Sammlung Niederlandisches Architekturinstitut, 1930s). I will discuss this work in the Conclusion.

¹¹⁰⁰ May, "Mechanisierung Des Wohnungsbaues." This "child's toy" served as May's primary instrument of motion study throughout this period and in his later work in the Soviet Union, linking it to instruction cards, gantt charts and more conventional plans and sections, modified to further examine the assembly logic of his system.

¹¹⁰¹ In *ibid.*, May included a comparison of brick construction and the Frankfurt System through an instruction card format. In the April 1929 RFG report and in the last publications of his experiments at Westhausen, from 1930, May used the same format to present the last four years of experimental work. "Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main." While the real cost of the panel system within the current political economy of Frankfurt was still higher than brick construction, the data showed significant improvements, informed by the gradual process of trial and error conducted by May and his team.

A similar attempt at simultaneously experimenting with the issues of construction and colonization exhibited at the settlement scale was also conducted at the unit scale during Phase II. May developed two new unit types, specifically for use in Praunheim Phase II, Type 5, a variant of Phase I's Type 2A, and Type 6, a variant of Phase I's Type 3E, as well as a Type 6Z (z for *Ziegel* or "brick"), a variant of Type 6, built in standard brick.¹¹⁰² (Fig. 212) All three types were further informed by the experiences of the ten experimental panel units from Phase I. Type 5, designed specifically for the northern side of a street, was ultimately seen as less successful, both by May and the RFG, in terms of solar orientation, the degree of privacy afforded the street-facing living room and the placement of the stair, among other problems.¹¹⁰³ (Fig. 213) Type 6, designed specifically for the southern side of a street, was decidedly more successful in all of the areas that Type 5 had been criticized, and would therefore serve as the foundation for the next type, Type 8, in Phase III. (Fig. 214) Although Type 6z shared many of the same qualities as Type 6, it was slightly smaller in surface area, due to the thickness of its load bearing walls.¹¹⁰⁴ All three types used

¹¹⁰² All three types shared a number of characteristics, including the same basic floor plan dimensions, a width of five hundred and thirty centimeters, from center to center of perimeter wall, a depth of eight hundred and seventy five centimeters from street façade to garden façade, the same number of levels, an ample cellar, a ground floor and an upper level. Some variation occurred among the types regarding the floor to ceiling dimension, and the extending walls, breaking the compact mass on the street and garden sides. The differences in orientation between the two panel units and the difference in building system between the panel and brick units resulted in a number of significant variations in the internal organization. In all three types, May sought to eliminate the odd fourth space from the 1926 type, by including the kitchen in a neat programmatic band that also included the stair and foyer, therefore leaving a larger living room.

¹¹⁰³ In Type 5 May rotated the stair parallel to the street line, reinforcing the division between that of the foyer and kitchen and that of the living room space. He then used the ten-centimeter ledge, generated by the difference in dimensions between the 30 centimeter foundation panels and the twenty centimeter exterior wall panels to lower the floor of the living room an additional thirty six centimeters, to a total clear height of three hundred and twenty one centimeters, as opposed to the two hundred eighty five, used in the other types. The second level included a large master bedroom, facing the street, as well as a bathroom and children's bedroom, facing the garden.

¹¹⁰⁴ In Type 6, a similarly sized, but flat, living room now faced the garden and block interior, with a smaller entry vestibule, and stair, placed perpendicular to the street and kitchen, to the north, where the street was located. In this type variant, the second level included a smaller master bedroom, bath and two small children's bedrooms, one whose closets pushed out into the stair core space. Due to the slightly thicker wall

Frankfurt Norm windows and doors, standards that were still tentative and whose dimensions would only be fixed after this experimental work.¹¹⁰⁵ (Fig. 215,216)

RFG Report on Praunheim, April 1929

The April 1929 RFG report on May's experimental work in Frankfurt, overseen by Walter Gropius on behalf of the advisory council, combined overall praise with a number of specific critiques ranging from fabrication and construction, to settlement and unit design.¹¹⁰⁶ One of the most revealing critiques of May's experimental work, in terms of significant differences of opinion as to what constituted a systematic approach to architecture, was expressed in the assessment of the Frankfurt panels themselves. While the report praised May's research into the use of volcanic pumice dust in his concrete mix, a material readily available in a "limited radius around the Neuwid Basin" and easy to ship to Frankfurt by barge, and which gave the panels a significantly increased thermal and hydrological performance, as compared to other concrete mixes, this was also seen as a flaw, since the material was not available "in all of Germany".¹¹⁰⁷ For May, the use of this

depth of the brick construction, the livable area of Type 6Z was somewhat smaller, although the openings were comparable in size. The ground level was essentially identical to Type 6, while the upper level had the more amply sized master bedroom and single children's bedroom dimensions of Type 5.

¹¹⁰⁵ In the finishing of the environmental enclosures of some of the units, a cement gun technique had been attempted, but proved ineffective, both due to unevenness of the surface and the roughness of the edges it left behind, causing problems for the installation of other manufactured elements, such as windows and doors. All three types had variants modified for edge conditions of the rows, with entries and windows shifted, primarily to reinforce the reading of the grouping as a more singular composition.

¹¹⁰⁶ "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." As in the report on Gropius' work, it was acknowledged that the recent completion of construction and settlement of the units made the report provisional, with additional visits to occur over the period of the ten year contract between the association and the municipality. A clear bias on the part of the RFG for *Zellenbau* settlement design was also evident here as it was in the discussion of Törten.

¹¹⁰⁷ Ibid. As the RFG report indicated, May himself had conducted experiments in replacing pumice dust with other materials, including fly ash and slag concrete mixes, as well as ceramics, but admitted that "none of these experiments had succeeded" in replacing the particular qualities of the mix, which allowed for rapid curing and good thermal insulation, among other characteristics. The RFG also encouraged May to experiment with smaller or larger panels that would allow more flexibility during the design process, as it had done for Gropius, a suggestion May did not take up in Frankfurt, but would explore later, in the Soviet Union

local material, in a new and more efficient way, was the essence not only of an industrial approach to architecture, but also one that was rooted in his understanding of vernacular architecture. Furthermore, it was the organizational logics that led to the choice of this material, and not the material itself, that were exportable, not only to other parts of Germany, but abroad as well. While May's special ingredient would be retained throughout the experimental work, the Visintini beams, which had proven problematic, in fabrication, transportation and assembly, were replaced, through a series of trials, by a lost concrete tile system.¹¹⁰⁸ The RFG report reinforced another of May's experimentally derived conclusions, namely that the advantages of the factory-like conditions at the Frankfurt Fair did not warrant the significant costs that a facility like that generated. As with the shift to the lost tile construction system, the shift from the Fair to an open-air temporary plant, located in Frankfurt's industrial East Harbor, had begun before the report was even issued, with a positive assessment of this new approach also included in April 1929.¹¹⁰⁹ The report also praised May's experimentation with alternatives to traditional stucco exterior finishes, while accepting the conclusions of those studies, which showed that new technologies, like cement guns, were not necessarily more efficient, in terms of cost or quality.¹¹¹⁰

¹¹⁰⁸ Ibid. Although the RFG's reports found that the beams were generally performing well in most of the units, the basement levels were an exception. It seems that workers were choosing to place the most poorly fabricated beams in the basement level, where there was less scrutiny during inspection. Whereas the pumice panels had been informed by standard methods from America but customized, in dimension and material properties for the more particular conditions of the Frankfurt housing program, the Visintini system had been taken directly from industrial and infrastructural building, where it was used for larger spans and in less climate controlled spaces than housing, with relatively little modification.

¹¹⁰⁹ Ibid. He was considering this in February 1928, before the report.

¹¹¹⁰ Ibid. May's application of conventional stucco finishes to the panel houses, a decision which some scholars have seen as proof of the lack of real industrialization of the Frankfurt System, was viewed by the RFG as a natural, even exemplary, result of the architect's experimental work, directly informed by contemporary industrial practice and fully in line with the goals of the association. The experiments in applying stucco in factory conditions, at the Fair, or the mechanization of its application, through spraying on site, had been analyzed through "scientific studies" and through more practical applications. This process, the

In general, the report called for more detailed “time and motion studies” to be conducted at the new outdoor fabrication facility and on the construction site in the future phases of experimental work, to supplement the “laboratory experiments” conducted by the building science institutes in Munich and Darmstadt.¹¹¹¹ The RFG had found May’s system successful in the first of his two stated goals, the “reduction of construction time”, but not in his second, the “cheapening of house building”, as the Frankfurt System was still 12% more expensive than brick construction, due primarily to the significant upfront investments and the relatively small scale of units constructed at that time.¹¹¹² The shift from two different contractors, one working on fabrication, at the Fair, and another on the construction of the site, to a single contractor, the privately owned Philipp Holzmann A. G., working at the East Harbor site, was also seen as a potential for further efficiency and economy.¹¹¹³ The municipality’s own research and that of the independent institutes, such as the RFG, as well as the post occupancy surveys of the first “colonists”, all suggested that the panels, when properly fabricated and assembled, performed quite well, with “no cracks in the plaster” and no “moisture in the walls”.¹¹¹⁴

The report was more critical of May’s work in terms of the systematization of dwelling, than it had been with regard to fabrication or construction. The Phase II types

data collected and the analysis tools used, constituted contemporary industrial practice, not simply production in factories or the use of mechanization.

¹¹¹¹ Ibid.

¹¹¹² Ibid. The report did praise the impressive achievements of May’s experimental system, including its rapid hardening time of two days, before removal of the forms, the daily fabrication output, with enough panels for two units in a single day, despite the limited size of the Fair pavilions, and, most of all, the rapid assembly of a typical panel house. The 76 square meter house Type 6 took 18 men, 45% skilled and 55% unskilled, 1.5 days, or a total of 230 working hours, as opposed to a brick house with a wooden roof, which took 3.5 days.

¹¹¹³ Ibid. Although the RFG would not have the opportunity to conduct more studies on these or later phases of May’s experimental program, the subsequent work at the East Harbor fabrication facility, at Praunheim Phase III and at Westhausen demonstrates a continued process of experimentation and evolution of the system, one that addressed a number of the errors identified in April 1929.

¹¹¹⁴ Ibid.

were criticized for their solar orientation, arguing that this problem could not be resolved at the unit scale but could only be addressed through the design of the settlement as a whole.¹¹¹⁵ The report praised the ample 25-meter living room spaces, each with optimal southern exposure, but was critical of the entry sequence of Type 5, which had a door opening directly into the living room from the street.¹¹¹⁶ While Type 6 was seen to have resolved the ground plan successfully, the addition of a third bedroom had resulted in three barely usable rooms, best exemplified by the master bedroom being too small for a standard adult bed.¹¹¹⁷ Another criticism of the units, informed by early post occupancy studies, was that the smaller Frankfurt Norm windows prevented the airing out of bedding from the window.¹¹¹⁸

The “Frankfurt Kitchens” were given the most detailed analysis of any aspect of dwelling in the report.¹¹¹⁹ As with the unit types themselves, the Frankfurt kitchen had evolved from Phase I into two different variants in Phase II. (Fig. 217) Post occupancy surveys indicated that the more direct connection between the kitchen and living room found in Type 6 was preferred over Type 5.¹¹²⁰ In general, more square spatial arrangements were preferred to the more elongated rectangular ones, and kitchens that faced the street, like the one in Type 6, were preferable to those that faced gardens, like the

¹¹¹⁵ Ibid.

¹¹¹⁶ Ibid. Post occupancy surveys critiqued the lack of privacy and the drafts caused by this design decision.

¹¹¹⁷ Ibid. The residents also chose to wash their laundry at home, rather than using the “experimental” communal Laundromat, further cramping an already small second floor bathroom. A second Laundromat had been planned for Praunheim Phase III but was never built.

¹¹¹⁸ Ibid.

¹¹¹⁹ Ibid. The kitchen was the subject of a number of articles by members of the RFG board in 1928. Marie-Elisabeth Luders, “Erst Die Küche - Dann Die Fassade!,” *ibid.* Sonderheft Nr. 2, no. Gruppe II 6, NR. 2 (June 1928). Paul Mebes, “Gedanken Zur Kuchengestaltung,” *ibid.* Wilhelm Lubbert, “Rationelle Kuchengestaltung,” *ibid.*

¹¹²⁰ “Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren),” *ibid.* Sonderheft Nr. 4, no. Gruppe IV, NR. 1 (April 1929). In Type 5 this awkward arrangement led to the residents choosing to eat in the living room instead of the small vestibule-parlor, separated from the kitchen by two doors.

one in Type 5, since they allowed mothers to watch children playing. Surveys also included praise of more specific features, including the rack that allowed for the storage of still wet pots, the easily cleanable concrete floors and surfaces, and the mechanical ventilation hood. They were more critical of the set of eighteen aluminum “raw material” containers, complaining that they were placed too low on the counter and were generally too numerous. (Fig. 218) The RFG concluded that twelve containers would be more optimal.¹¹²¹ Despite some of these critiques, Greta Schütte Lihotzky, the designer of this set of tentative standards, was praised for her willingness to experiment, even if this “organization overshot the goal”.¹¹²² This discussion on the Frankfurt Kitchen epitomizes the idea of typification or standardization as being a creative process through which tentative standards or types, to assist in the systematic management of dwelling, were developed through a laboratory method that included the “observation of living habits”.¹¹²³

May’s Experimental Work after the Report, 1929-1930

While the 1929 report demonstrated May’s impressive ability to manage a complex and experimental housing delivery program, simultaneously, prior to 1929, subsequent challenges generated by a lack of political consensus regarding the Frankfurt housing program, already present in 1925 and exacerbated by the economic crisis of 1929, proved much more difficult to overcome.¹¹²⁴ In the name of their constituencies, the parties that made up the ruling coalition, the SPD, DDP and Center, all began to place even more pressure, adding to the list of demands and criticisms of the housing program already held

¹¹²¹ This experimental work directly informed the Munich Kitchen, which had twelve containers and was also more directly connected to the living room. "Ausschuss 2 - Vorhandene Bauten - Tätigkeitsbericht," 16-17.

¹¹²² "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)."

¹¹²³ *Ibid.*, 16-17.

¹¹²⁴ May, "Fünf Jahre Wohnungsbautätigkeit in Frankfurt Am Main." Inflation had caused a 185% increase in the cost of construction, as compared to the prewar period, by 1928, and 190% by 1930. Capital costs grew even more significantly, exceeding prewar levels by 250%.

by opposition parties to the Left and Right.¹¹²⁵ This general lack of consensus led May to shift his experimental fabrication work from the municipally owned Frankfurt Fair, where he employed the predominantly municipally owned contractor, *Preußisch-Hessische Bau- und Finanzgesellschaft*, to a rented space from Frankfurt's Harbor Authority in the industrial East Harbor, where he employed Holzmann Contractors, a private firm, that had already been engaged in panel assembly work at Praunheim. (Fig 219) On January 1, 1928, May explained to his fellow council members that he would go "without ... municipal funds", "renounce ... the hall" at the fair, and "fabricate outdoors", at East Harbor, further experimenting with and standardizing his system, before "obtaining ... sufficient funds" to construct "sheds" where the production would be moved once it was fully refined.¹¹²⁶ While he had hoped to begin operation there in the spring, actual production did not begin until October 1928. Following the same rigorous experimentation and standardization program he had already used to optimize his system for fabrication indoors, May repeated more "scientific" experiments in fabrication of his panels outdoors, in August 1928, turning to experiments in transportation and assembly from the facility by Holzmann, in September 1928.¹¹²⁷ The last of these experiments, examining the shrinkage and elasticity of one of the first batch of panels, cast outdoors in the summer, coincided with the

¹¹²⁵ The SPD and the KPD insisted on further reducing the size of the dwellings, hoping to reduce the cost, while the Center and DDP parties continued to oppose the municipal support of May's industrialization of building. May found all of the Parties equally short sighted. He was particularly critical of the small, substandard housing called for by the SPD and KPD, fearing it would simply result in the same socio-economic problems of the earlier tenement types, albeit now funded with municipal money. As such, May attempted at Praunheim Phase III to provide the smallest possible row-house unit, with the capacity to transform into more ample units; following the spirit of the DI-Norms, he felt that his research into industrialized housing delivery was a valid municipal investment, one that would benefit the various constituencies represented over the long-term. For more on the debate within the municipal council, see Kuhn, "'Frankfurter Fordismus'."

¹¹²⁶ Ibid.

¹¹²⁷ "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." This data was complemented by the feedback received from the first post-occupancy surveys of the recently settled experimental units at Praunheim Phase II.

beginning of mass production at the East Harbor, in October 1928.¹¹²⁸ The larger fabrication fields of the East Harbor were directly accessible to barges, which brought raw materials directly to pulverization and mixing machines, from which smaller cranes could then scoop the mixtures, placing them directly into the simple, flexible forms, running for hundreds of meters along the site. Two large mobile gantry cranes, on tracks, lifted the partially cured panels from the forms, stacking them to cure. While curing time did increase due to the outdoor conditions, this increase did not have a significant impact on subsequent processes. The first panels fabricated in this manner were assembled into the 216 new experimental units at Praunheim Phase III, in the spring of 1929.¹¹²⁹

Praunheim Phase III

Responding to feedback from his own work, the RFG report and post occupancy studies, May developed a new type for Phase III, Type 8.¹¹³⁰ (Fig. 220) At the unit scale, the changes were primarily related to the *systematic management of dwelling*, the most significant being the orientation of the house-row back to the more optimal solar orientation of the first ten experimental units. This type was designed to be grouped on both sides of a secondary traffic corridor, but now oriented north south, instead of east west. May was still able to achieve enclosedness with this type, as demonstrated on the northern end, through small groupings of buildings around courts. Rhythm was added to

¹¹²⁸ Ibid. Through the East Harbor facility, May was able to take further advantage of his highly localized system, as the essential ingredient of his panels, pumice, now arrived directly to the fabrication facility from quarries in the Neuwied Basin, via barges floating along the Rhine and Main Rivers.

¹¹²⁹ Ibid. Fabrication at the East Harbor facility was studied and positively assessed by the RFG in April 1929. Here, May came even closer to the root logics of Conzelman's Unit System, which was already optimized for outdoor fabrication.

¹¹³⁰ Type 8 was developed between the completion of construction of Phase II, in June 1928, and its settlement, in August. "Siedlung Prauhheim." In terms of fabrication, May was already planning to shift to the East Harbor, anticipating that this change in site would not impact the panels themselves, their assembly, or their finishing. The replacement of Visintini beams did not seem to have a significant impact in the logic of this unit.

the street space itself, by eliminating a unit on the western street face, and exceptional units formed gateways on the eastern face, in order to allow pedestrian east-west paths to cut through, and longer vistas towards the new cemetery, to the south. Type 8 had a significantly smaller frontage than Types 5 and 6, but with only a slightly shallower depth.¹¹³¹ This resulted in a similar stair and kitchen and smaller foyer towards the street, and a smaller living room of eighteen, instead of twenty-five, square meters now oriented towards the garden side.¹¹³² The second level included a master bedroom, comparable in size to the Type 5, and larger than the one criticized in Type 6, with a significantly larger window, a small bathroom, now equipped with a shower, and a small, but better organized second children's bedroom.¹¹³³ The single unit was planned and deployed 216 times within a settlement scheme that maintained adequate insolation for units on both sides of the street, while also providing a well defined street space. By preserving the now normed opening dimension and narrowing the overall dimensions of the unit, May achieved a much more modernist reading of the overall unit, with the first and second floor windows now reading less as punched openings and instead creating a sense of continuity between living room and garden, through the extension of the walls on this side.¹¹³⁴ May found this experimental unit successful enough to include in the set of *Frankfurter Typengrundrisse*, or "Frankfurter Type Plans", one of the eighteen types that had been *evolved* through his laboratory work. Instead of the serial number, Type 8, the unit was now christened EFA 3.56, with the letters standing for *Einfamilienhaus*, or "Single Family House", the first

¹¹³¹ Type 8 had a significantly smaller frontage of four hundred and thirty centimeters, instead of the five hundred and thirty centimeters of Types 5 and 6. The new, shallower depth used the standard panel dimensions more efficiently.

¹¹³² The more ample foyer would now ensure a more gradual threshold, in terms of privacy and drafts, between the public and private realms.

¹¹³³ May still hoped for centralized laundry, although it was never built in phase III.

¹¹³⁴ May removed the walls on the street side, therefore lowering the amount of panel material required.

number referring to the number of rooms and the second number referring to the livable area.¹¹³⁵ Even this evolved type remained a tentative standard, which was endorsed, not enforced, by the municipality.

The same shift from more experimental to standardization work shown in the unit scale also occurred at the settlement scale in Phase III. Since the earlier strategy to construct the settlement infrastructure in order to assist in the assembly process in Phase II had proven uneconomical, with the cost incurred by the damage done during construction not being balanced with benefits in speed or cost of assembly, May decided to postpone much of the settlement infrastructure, such as the paving of the streets, until after the panel units were assembled. This decision made the organization of the temporary construction plant even more crucial, as demonstrated in his *Baustellenbetriebsplan*, or “construction management plan”, for Phase III.¹¹³⁶ (Fig. 221) Here, the routing of the flows of transportation of materials and equipment, as well as their staging, was organized along the more ample future spaces of the allotment gardens, not the roads. Electrical and water infrastructure from the recently completed Phase II was extended enough to support the needs of the temporary construction plant, until the final extensions of these services, planned for after the erection of the panel units, was completed. Like the host of other instruments and methods of data management borrowed from contemporary industry and applied to the housing program since April 1926, this routing plan not only optimized the erection of the panel units, but was used to manage the construction of the brick row-houses, as well as the multi-story structures along the future transit and commercial hub

¹¹³⁵ May, "Housing Policy of Frankfurt."

¹¹³⁶ "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." Here, May used the gantt chart extracted from Phase II to plan Phase III.

along Hindenburg-Allee.¹¹³⁷ While the RFG would not have the opportunity to assess Phase III, the modifications to May's industrialized housing delivery nevertheless proved successful enough for the architect to continue to apply, and refine, them through his last settlement project in Frankfurt, Westhausen.

Westhausen Siedlung, 1929-1931

Although Praunheim was the only designated "experimental settlement" in Frankfurt, May would continue his experimental work, contracted by the RFG, through the design and construction of 378 "experimental units" at Westhausen Siedlung, located south of Praunheim, immediately on the other side of city cemetery.¹¹³⁸ Westhausen would be the most explicitly *Zeilenbau* organized schemes of May's Frankfurt settlements. In addition to the general advocacy for this mode of settlement organization, May seems to have been motivated by the idea that, like the perimeter block of the mid 19th century, typical to regulation planning, or the superblock, typical to the garden city, the *Zeilenbau* settlement was seen as an *established* standard, and as such should be experimented with.¹¹³⁹ (Fig.

223) May, like many other modernist settlement-builders, borrowed the basic structure of

¹¹³⁷ It was Praunheim's Phase III, still an organizational artifact in the process of becoming a physical one, which awaited the participants of CIAM II, hosted by May in his hometown in October 1929.

¹¹³⁸ Manfredo Tafuri has used Westhausen's more rectilinear geometry and repetition of units to prove May's acceptance of "rationalist *Siedlung*" design methodology, one that more politically progressive German architects, including Martin Wagner and Ludwig Hilberseimer had adopted years earlier. Here the architect abandoned the "game" and the Anglo-Saxon theories of his youth, and sought to merely distract the residents of these colonies from real problems through purely visual demonstrations of "the infinite capacity of the 'type' to vary itself, while remaining itself." This reading, which is often repeated by later scholars, conflates ideological positions and formal languages, missing the most important social and formal goals of May's last Frankfurt *Siedlung*, as well as its consistency with May's evolutionary understanding of types, rooted in the productive Anglo-German exchange of his youth, and the RFG's attempt to develop a national scale program of experimental derivation of standard methods for systematically managing the construction site and the dwelling. Tafuri, *The Sphere and the Labyrinth: Avant-Gardes and Architecture from Piranesi to the 1970's*.

¹¹³⁹ These two phases were seen by May as part of the "evolution of the modern block and parcel plan", to which he had added his own work at Praunheim, slightly abstracted, as well as the planned organization at Westhausen, as the fourth iteration. (Fig. XX) There was nothing new about the *Zeilenbau* organization itself, Unwin had pointed to its existence in Italian and French vernacular fabric, and had already diagrammed its basic characteristic in 1909. The difference now was that some consensus had been reached that this schema was particularly suited to contemporary conditions, and it had been identified as a kind of superstandard.

the *Zeilenbau* settlement from Unwin's 1909 manual on town planning. Furthermore, May was under pressure, both from the municipal council and from his peers, to move away from the row-house unit to other multi-unit housing types. As a result, May would use Westhausen as an opportunity to push his own row-house typology to the highest density he felt was still socially appropriate.¹¹⁴⁰ (Fig. 224)

The first reworking of the typical *Zeilenbau* configuration is visible in the four gallery apartment buildings, not part of the experimental development of the Frankfurt System. Here, May used these larger slabs to define an edge with the busy traffic corridor along Hindeburgstrasse at the settlement scale, while providing additional privacy to each of the units, at the building scale, by orienting the units to the more ample shared gardens. The small units were given wide, shallow south facing living rooms, which provided light to the north-facing kitchen. The views of the residents' gardens, visible from the galleries immediately north, were parallel to the view of the row-house units, which themselves read more like gardens, to the west, a revised *landform* strategy for flat land, viewed from above, from the earlier strategy of groups of houses lifted above the viewer, by topography, at Praunheim. (Fig. 225) May's earlier experiences with the management of settlement-scale construction at Praunheim Phases II and III, as well as at *Mammolshein*, led him to critically assess the benefits of the *Zeilenbau* configuration. At Westhausen, materials and building components travelled and were staged along the larger, east-west oriented future

¹¹⁴⁰ Here, one of Gropius' diagrams, included in his winning entry for the Spandau-Hasselhorst research settlement competition, on whose jury May served, probably informed this decision. In that diagram, Gropius showed a range of configurations of the same overall unit density organized in six schemes, ranging from single story row houses to the massive slabs that would come to dominate postwar housing delivery. This diagram, a further abstraction of the four schemes presented for the competition, was published in Walter Gropius, "Flach-, Mittel-, Oder Hochbau?," *Das Neue Frankfurt: Internationale Monatsschrift für Die Probleme Kultureller Neugestaltung* 5, no. 2 (February 1930). The scheme at Westhausen sought to demonstrate that a density more attuned to the wishes of the future residents for low-rise buildings could still be reached.

common greens, while the tower cranes moved along each by way of the north-south strips of the future allotment gardens. While at Praunheim Phase II, relief to the building line and some adjustment to the topography came primarily from shifts in plan, and at Phase III, through the ruptures and special units marking the east-west pedestrian paths, here units were allowed to more gradually register the changing topography, a feature that is imperceptible in the widely published aerial photographs of the still unfinished project, but highly discernable when walking through the dense allotment garden landscape of the completed project. Although May finally gave in to the calls for the maximum quantity of minimum units, the units, as well as their load bearing structure, were designed so as to make their future conversion into row-houses possible.¹¹⁴¹ During the first phase of construction of Westhausen, while the RFG was still in existence, May also conducted his most extensive motion studies to date, staging “progress photos” to assist in the further standardization of his experimental method of fabrication and assembly.¹¹⁴² (Fig. 226) These studies also show the replacement of some of the interior walls with single Wythe brick walls, as well as the introduction of reusable steel scaffolding for the erection of the lost concrete panel floors. The first phase of Westhausen was completed by the time May was invited on a lecture tour of the Soviet Union, in April 1930. With May, as well as the

¹¹⁴¹ The same basic settlement scheme supported nearly 5,000 residents during the first decades of its existence but was reduced to 2,000 residents by 1979, two years before the Mammolshainerstrasse minimal units were demolished, due to their poor state of maintenance and the impossibility of their adaptation and expansion. For more on this see Dreyse, *Ernst May Housing Estates: Architectural Guide to Eight New Frankfurt Estates 1926-1930*.

¹¹⁴² With the system mostly defined by 1929, May began staging progress photos of the assembly to further standardize and optimize the experimentally derived standard method.

RFG, no longer managing the experimental work, Westhausen would be completed using more conventional brick construction in 1931.¹¹⁴³

Conclusion

Between 1926 and 1930, Walter Gropius and Ernst May had a unique opportunity to experimentally derive and standardize systems of building and dwelling, through the support of the experimental settlements program, initially under the umbrella of the National Committee on Types and, after 1927, the RFG. In Dessau and Törten, the two architects managed the conception, construction and colonization of their respective settlements in response to a specific problem and with the aims of generating knowledge, through this activity. Their experimental settlements built directly upon the earlier work of Frederick Taylor and Frank Gilbreth, Hermann Muthesius and Raymond Unwin, and Le Corbusier and Martin Wagner. They came closest to achieving a scientifically managed mode of architectural work, one that fused the spaces of inquiry and that of production. While these experiences, as well as the standard methods, tools and parameters they derived through their experimental settlements informed their subsequent work, there is no evidence in their own subsequent writings, proposals or in the literature in general, of either architects repeating this kind of activity. In the Conclusion I will hypothesize what might have limited the possibilities for similar projects in the postwar period, precisely when industrialized housing delivery became prevalent in Europe and North America.

¹¹⁴³ The most thorough account of May's work in the Soviet Union to date is included in Thomas Flierl, "'Possibly the Greatest Task Ever Faced': Ernst May and the Soviet Union: 1930-1933," in *Ernst May: 1886-1970*, ed. Wolfgang Voigt Claudia Quirling, Peter Cachola Schmal, Eckhard Herrel (Munich: Prestel, 2011).

Conclusion. Bureaucratizing, Over-Bureaucratizing and Self-Managing the Laboratory Method

In the first portion of this dissertation I identified the two key characteristics that distinguished scientific management from other forms of industrial organization at the turn of the last century. The first characteristic, the laboratory method, is marked by its linked activities of experimentation and standardization, a method most often attributed to Frederick Taylor, and the second characteristic is the visualization and projection instruments of Frank and Lillian Gilbreth, developed specifically to assist with the laboratory method. I have also identified the key roles played by Hermann Muthesius, who offered a theoretical disciplinary foundation, and Raymond Unwin, whose system of settlement design already drew on the principles of industrial organization, in providing a framework with which the laboratory method and the instruments and methods of the Gilbreth's visualization theory could be translated into architectural practice. Through an examination of how scientific management was first applied to the management of industrialized settlement-building by American engineers, I was able to better assess the early attempts of European modern architects in their own application of these principles to their intellectual work as it related to a series of feedback loops between, conception and projection, projection and construction, as well as construction and occupation. While a number of architects, including Peter Behrens, Martin Wagner and Walter Gropius all applied the principles of scientific management to their intellectual work, I have found that two architects pursued this endeavor with exceeding rigor, the first being Le Corbusier, through his work in and near Bordeaux, between 1923 and 1926, and Ernst May, through his work in Frankfurt, between 1926 and 1930.

Both Taylor's laboratory method and the Gilbreths' visualization theory were thoroughly discussed by European modern architects during the twenties, and these principles were even applied at some of the most publicized early examples of modern architecture, such as Pessac and Praunheim. However, there is less indication that the theories and instruments of scientific management had a permanent impact on the architectural discipline, especially when compared to a number of other fields, such as industrial engineering or computer science.¹¹⁴⁴ As I have shown, Le Corbusier chose to erase many of the traces of the important and productive *errors* of his *trials* in Bordeaux from later editions of the *Oeuvre Complete*, between 1929 and 1936, just as any mention of Taylor, *Taylorisme*, and Taylorization, were eliminated from the English translations of *Toward A (New) Architecture*. Le Corbusier's own revisions paralleled, and were probably informed by, the construction of a new ontological model, as epitomized in a passage from *Space, Time and Architecture*:

This new representation of space was accomplished step by step, much as laboratory research gradually arrives at its conclusions through long experimentation; and yet, as always with real art and great science, the results came up out of the subconscious suddenly.¹¹⁴⁵

For Giedion, Le Corbusier's work was a product of deduction and intuition, not experimentation. A few years after this passage was written, Henry Russell Hitchcock, the inventor of the International Style, moved architectural discourse even further from the ideas of the laboratory method, by dividing architectural production into two distinct areas, the "architecture of genius", where Le Corbusier's work was now placed, and the

¹¹⁴⁴ The tentative standards that regulate the production of Big Macs and iPhones, or the distribution networks of FedEx or Amazon, today are projected according to the laboratory method with Gantt charts and critical path plans, while architectural production, despite its digitalization, is not, or certainly not to this extent. That is not to say that architectural production is not also regulated by tentative standards but that architects are neither involved in their production nor are they familiar with the systems that produce them.

¹¹⁴⁵ Sigfried Giedion, *Space, Time and Architecture* (1960 [1940]), 437.

“architecture of bureaucracy”, where the interwar work at Pessac and Praunheim, as well as Ernst May’s postwar work in West Germany, would have resided.¹¹⁴⁶ While this shift in discourse was not necessarily matched in practice, as exemplified by Charles Eames’ significant interest in industrial engineering and motion studies within his 1944 discussion of “what is a house”¹¹⁴⁷ (Fig. 227), or Skidmore Owings and Merrill’s design team using a variant of a Gilbrethian route model¹¹⁴⁸ (Fig. 228) to discuss the organization of the Connecticut Life Insurance Company’s new post-industrial plant nearly a decade later, but these approaches would essentially be quarantined away from central architectural discourse. Over the second half of the last century, modern architecture, including the work of Le Corbusier and Ernst May, has been entirely subsumed into the avant-garde art movements of the early twentieth century. For example, Manfredo Tafuri discussed the “architectural avant-gardes” interchangeably with Picasso or Malevich, arguing that the “existence of a deep contradiction between the avant-garde and experimentalism has already been accepted”.¹¹⁴⁹ The avant-gardes were “always affirmative, absolutist, totalitarian”, executing a right to “ignore existing materials”, as opposed to those engaged in experimentalism, which “is on the contrary ... constantly taking apart, putting together, contradicting, and provoking languages and syntaxes that are nevertheless accepted as such.”¹¹⁵⁰ As such, he argued “(i)ts innovations can be bravely launched towards the unknown, but the launching pad is solidly anchored to the ground.”¹¹⁵¹ Since Tafuri

¹¹⁴⁶ Henry Russell Hitchcock, “The Architecture of Bureaucracy and the Architecture of Genius,” *Architectural Review* 101, no. 601 (1947).

¹¹⁴⁷ John Etanza Charles Eames, “What Is a House?,” *Art and Architecture Prefabrication* (July 1944).

¹¹⁴⁸ Carol Herselle Krinsky, *Gordon Bunshaft of Skidmore, Owings & Merrill* (Cambridge: The MIT Press, 1988).

¹¹⁴⁹ Manfredo Tafuri, *Theories and History of Architecture*, trans. Giorgio Verrecchia (New York: Harper, 1980 (1976)).

¹¹⁵⁰ *Ibid.*

¹¹⁵¹ *Ibid.*

provided no examples of “architectural experimental research”, essentially all of interwar modern architecture, as opposed to the wealth of examples of avant-garde work, it is difficult to know to what exactly he is referring to, but nevertheless, the work I have discussed in this dissertation is much closer to his definition.

An experimentalist approach to architectural production in the postwar period, which is specifically rooted in the interwar work I have discussed, can be detected in the work of Charles and Ray Eames, SOM as well as the firm that Walter Gropius would be asked to join as a founding partner, The Architects’ Collaborative, or TAC.¹¹⁵² My own research has also found another trajectory of the evolution and adaptation of experimentalist architecture, one that follows Ernst May’s move east to the Soviet Union and the later movement, south, of his work from the Soviet Union to postwar Yugoslavia. Here, this experimentalist architecture would eventually attract the attention of an international group of artists and theorists who had come together to consider the role of the computer in art and architectural production, the New Tendencies Movement. A sketch of this trajectory also offers an interesting set of transitions, from the municipal bureaucratization that provided the foundation for May’s laboratory work in Frankfurt, to the *over-bureaucratization* of the Soviet Union, to the self-managing socialism of Yugoslavia.

¹¹⁵² Discussions regarding Gropius’ role in the organization of TAC during the postwar period with Michael Kubo, a doctoral candidate at the Massachusetts Institute of Technology currently working on this topic, have led us to conclude that this may be the most direct evolution of the German architect’s earlier interest in American industrial management.

From Bureaucratization to Over-bureaucratization: Ernst May, 1930-1932

On October 5, 1930, Ernst May and twenty architects, many of who had worked with him in Frankfurt, arrived in Moscow.¹¹⁵³ May was appointed Chief Engineer of *Standartgorproekt*, or “Standardized Town Project Bureau”, a department of the *Cekombank*, or “Central Communal Bank”, an entity created as part of the first Soviet Five Year plan (1928-1932) to deliver housing in the form of socialist company towns appended to the Soviet Union’s new industrial centers. Throughout the fall of that year, May and his team, the May Brigade, toured a number of newly established industrial centers, including Magnitogorsk. By April 1931, *Cekombank* was absorbed into a new, even larger entity, the *Soyuzstandartzilstroii* (Union for Standard House-building), following the pattern of increased centralization that marked the end of the more chaotic NEP period of the twenties. During this first intensive year, May and his team prepared multiple town plans for Magnitogorsk, Novosibirsk, and Sotsgorod Avtostroy, the Soviet Union’s answer to Detroit, the Motor City, as well as a number of other schemes, each one larger than the settlements of New Frankfurt combined. When May returned to Germany, to give a lecture in Berlin on his Soviet work, on June 5, 1931, he wowed his colleagues with a scale, as well as a power, that was unmatched anywhere in Europe at that time. At that time, it seemed that May, informed by his experimentation and standardization work in Frankfurt, which had been subsidized by the municipal and national funds of the now disbanded RFG, now had the unique opportunity to apply this experience to what was “possibly the greatest task

¹¹⁵³ For a history of May’s work in the Soviet Union see Thomas Flierl, “‘Possibly the Greatest Task Ever Faced’: Ernst May and the Soviet Union: 1930-1933,” in *Ernst May: 1886-1970*, ed. Wolfgang Voigt Claudia Quirling, Peter Cachola Schmal, Eckhard Herrel (Munich: Prestel, 2011).

an architect ever faced.”¹¹⁵⁴ Instead of working at a municipal scale and negotiating with the myriad interests of Weimar’s political parties, May was now the head of what was essentially a continental-scale housing delivery operation. In early 1932, May would test his unique position in a competition for the Soviet Union’s capital, Moscow.¹¹⁵⁵ However, not only did he fail to win this important commission, but on January 30, May’s position as Chief Engineer was terminated, effective April 1. The German architect was then demoted to a lower position, which included a Russian supervisor to correct his work. While May and his team continued to work in these more compromised conditions for more than a year, attempting to translate their methods to the Soviet context, May, and a number of other members of the May Brigade, would begin to leave the Soviet Union, in late 1933. Despite a number of difficulties, the architects were able to realize a number of their projects, however, there is no indication that the kind of work in experimentation and standardization, which that they had conducted in Frankfurt, was continued in the Soviet Union.

In Frankfurt, a number of concurrent factors had contributed to an organizational infrastructure that provided enough stability, as well as flexibility, for experimentation. To conduct an experiment, a significant percentage of parameters need to be controlled so that a few parameters may be variable in order to generate feedback through a process of trial and error. Even during the first year of May’s tenure, when he held the post of Chief Engineer, there seems to have been little opportunity for this kind of iterative work. As the newly established Soviet bureaucracy evolved, during the first five year plan,

¹¹⁵⁴ A phrase from Ernst May’s June 1931 speech in Berlin.

¹¹⁵⁵ Timothy Colton, *Moscow: Governing the Socialist Metropolis* (Cambridge, MA: Belknap Press, 1995), 273-75.

bureaucratization seems to have moved into what Brenda Danet has termed “over-bureaucratization”, which she defines as a “situation in which the organization comes to dominate the environment, or fails to respond to legitimate needs and demands of the environment.”¹¹⁵⁶ Within this *organization situation*, not only experimentation, but also equilibrium, within a given system becomes difficult to manage, generating crisis, which in turn generates the perceived need for more organization or bureaucratization and less interest in feedback. In May’s case, the forced collectivization and industrialization of agriculture led to a massive increase in urban populations and, at the same time, to a severe food shortage, an accelerated restaging of the very conditions that had motivated advocacy for the garden city movement. Unfortunately, the architect, his foreign colleagues and their sophisticated housing proposals, proved to be convenient scapegoats for these problems, resulting in May’s demotion in early 1932.

While May was limited in his ability to practice the laboratory method, or to systematically manage settlement-building through the application of his experimentally derived standards, he did leave at least one tentative standard for industrialized housing delivery. Completed on August 18, 1931, *tipovoy proyekt 14*, or “Type Project 14”, had been informed by earlier work and was at least partially modified for this new context.¹¹⁵⁷ (Fig. 229, 230) Type Project 14 picked up where his standardization of project delivery had left off at Westhausen, and consisted of minimal units made up of two 311 centimeter wide and

¹¹⁵⁶ Mark R. Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power* (London: Harvard University Press, 1988), 1-2. Beissinger uses Danet’s theoretical model to analyze the application of scientific management to Soviet industry.

¹¹⁵⁷ These drawings are held at the Canadian Centre for Architecture, are included in Eve Blau and Edward Kaufman, *Architecture and Its Image: Four Centuries of Architectural Representations* (Montreal: Canadian Centre for Architecture, 1989). Much of May’s work during this period lacked the interscalar nature of the earlier Frankfurt work. This project is one of the few examples of the range in scale, from the building component to the urban ensemble, which had been typical at Praunheim and Westhausen.

approximately seven meter deep modules, placed along gallery circulation. Reflecting the lower degree of mechanization available on Russian construction sites, May reduced the size of his concrete panels, with five instead of three panels now constituting a floor. Borrowing an experimentally derived standard from Gropius, May introduced rapid beams for the floors of the system, but used them in such a way so as to eliminate the need for reinforcing in the wall panels, by spanning across the window openings. In the design of the temporary construction plant, May replaced steel cranes with wooden ones, but still maintained the use of steel rails. While he did not plan for the on-site fabrication of his smaller concrete panels, he was careful to minimize the amount of necessary motions, from delivery by truck to the final installation within the building structure, by carefully planning out the position of each prefabricated element, on the construction site, within easy reach of the tower crane. In general, May's drawing set was more detailed than any of the projections he had generated during his work in Frankfurt, reflecting the more bureaucratized context within which he now worked. While this particular standard was not utilized to manage settlement-building during the interwar period, it is strikingly similar, as a building system, to the first generation of postwar systems used in the Soviet Union, the *krupnoblochnoye*, or "big block method" of concrete construction¹¹⁵⁸. Likewise, it is similar, as a projection system, to the instruments used by Gropius at Torten, as well as to those that would later be widely used throughout the Soviet Union, which combined information about the final architectural product and temporary construction plant needed to produce it, in a single projection. Although a direct link between Project 14 and this later

¹¹⁵⁸ Colton, *Moscow: Governing the Socialist Metropolis*, 372.

work is difficult to map out, this project was almost certainly known by two individuals who would directly influence the postwar period, Aleksei Gastev and Nikita Khrushchev.

Aleksei Gastev, the prime proponent of *Organizatsiya Proizvodstva Kak Nauka*, or “scientific management”, and who had founded the Soviet Union’s Central Institute of Labor (TsIT), in part through an active correspondence with Frank Gilbreth, was also the head of the *Institut Norm i Standartov SSSR*, or the “Institute for Norms and Standards, USSR”, which was the sponsor of May’s “type project”.¹¹⁵⁹ (Fig. 231) Even though Gastev himself would later be demoted, in 1936, and ultimately murdered in one of the many Stalinist purges, in 1939, it is arguably a renewed interest in the TsIT’s work of the twenties, which led to the rediscovery of May’s work, during the postwar period. Nikita Khrushchev, who had risen to the post of second secretary of the Communist Party’s Moscow City Soviet at the same time that May had arrived in the Soviet capital, was also likely linked with this project. As Khrushchev would later explain in his memoirs, by 1931, he “became closely linked with construction work” and even claimed to have become an expert in “solving organizational problems in the construction of factories, housing, municipal services, schools, hospitals, everything that everyone needed.”¹¹⁶⁰ In addition to this organizational expertise, the future leader of the Soviet Union had also supposedly collaborated with Nikolai Bulganin, his immediate superior in the Moscow City Soviet, on manufacturing “large concrete blocks”, which were used “instead of bricks” to build a school in Moscow during this period, following methods included in “foreign literature.”¹¹⁶¹

¹¹⁵⁹ Kendall E. Bailes, “Alexei Gastev and the Soviet Controversy over Taylorism, 1918-24,” *Soviet Studies* XXIX, no. 3 (1977): 393.

¹¹⁶⁰ Nikita Sergeevich Khrushchev and Sergeĭ Khrushchev, ed. *Memoirs of Nikita Khrushchev*, vol. 2 Refomer 1945-1964 (The Pennsylvania State University 2006), 247.

¹¹⁶¹ *Ibid.*, 265.

While Khrushchev certainly fared better than Gastev during the Stalinist purges and World War II, he was essentially banished from the capital, back to his native Ukraine. There, he was tasked by Stalin to carry out the same disastrous agricultural policies of the thirties, during the early postwar period, instead of pursuing his “weakness for construction work and matters involving the municipal economy.”¹¹⁶² Nevertheless, Khrushchev was able to indulge his *weakness* during his Ukraine period, from 1943-1949, contributing to its position as a center for industrialized housing delivery systems, as evidenced by the leading role of the Ukrainian Academy of Architecture in the production of a number of early articles and manuals on *potochnoye stroitel'stvo poselkov*, or “routed settlement-building”.¹¹⁶³ One of the first manuals on the subject, titled *Raschot potochnogo stroitel'stva seriynykh zhilykh domov*, or “The Calculation of the Routed Building of Serialized Houses” (1959), suggests another potential link to May’s work, crediting the Magnitostroii Building Trust, from Magnitogorsk, as the first organization to practice this method of production, in 1946.¹¹⁶⁴ (Fig. 232) One of the most complete manuals on this subject, *Proyektirovaniye potochnogo zhilishchnogo stroitel'stva*, or “The Projecting of Routed House-Building”, was published in 1965, coinciding with Khrushchev’s own destalinization program. (Fig. 233) As part of this program, Khrushchev first removed Stalin’s own brand of management, embracing western management instead, before his rediscovery and reinstatement of Gastev’s socialized and Slavicized scientific management to prominence, through the publication of a collection of his articles, in 1966.

¹¹⁶² Ibid., 255.

¹¹⁶³ M. S. Budnikov, *Potochnoye Stroitel'stvo Poselkov* (Kiev: Publisher of the USSR Academy of Architecture, 1949).

¹¹⁶⁴ Aleksandr Mikhaylovich Klindukh, *Raschot Potochnogo Stroitel'stva Seriynykh Zhilykh Domov [the Calculation of the Routed Building of Serialized Housing]* (Kiev: Ukrainian SSR Publishing House of Literature on Building and Architecture, 1959), 2-3.

The manuals of routed settlement-building brought to the Ukraine included a full range of the visualization and projection instruments of scientific management, including individual and group instruction cards, or Gantt charts, simply called *tehnologii*, or “technologies”, as well as construction plant plans at various scales, from the individual slab to the settlement. (Fig. 234) A new projection instrument, founded upon the earlier process charts and *Zeitplans* of the interwar period, the *tsiklogramm*, or “cyclegraph”, was also presented in these publications. The cyclegraph was a complex projection instrument that allowed one to plan, or “route”, multiple tasks in space and time, accounting for more complex interactions between routes, while simultaneously determining the shortest possible overall route, similar to the Critical Path Method (CPM), which were consecutively developed by Du Pont for the design and management of their chemical factories.¹¹⁶⁵ While the cyclegraph could be projected orthographically, like a map or an architectural drawing, it could also be precisely calculated, using elaborate formulas that would be later be transferred to the computer.¹¹⁶⁶ The appearance of the cyclegraph in the Soviet Union, along with the critical path plan in America, reinforces German sociologist Max Weber’s theories regarding bureaucratization, which has been paraphrased more recently by James Beniger, who points out that “control can be increased not only by increasing the capability to process information but also by decreasing the amount of information to be processed,”

¹¹⁶⁵ The critical path method (CPM), was developed by the Engineering Control Group of the E. I. du Pont de Nemours and Company in 1956 and first used in 1957. Stuart G. Walesh, *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields* (Hoboken: Wiley, 2000), 145-47. For an account of Du Pont’s work leading up to CPM, see John C. Rumm, “Scientific Management and Industrial Engineering at Dupont,” in *A Mental Revolution: Scientific Management since Taylor*, ed. David Nelson (Columbus: Ohio State University Press, 1992).

¹¹⁶⁶ The use of computers in calculating and projecting routed settlement-building was discussed in the 1965 manual. Georgia, not the Ukraine, would take the lead in this field, as evidenced by one of the first articles on the subject, E. Kikodze Agababyan R., G. Chigogidze, “Primeneniye Vychislitel'nom Tekhniki V Arkhitekturnom Proyektirovanii [the Application of Computation Technology to Architectural Projection],” *Arkhitektura SSSR* 1(1964). For a more general discussion of the computerization of Soviet bureaucracy see Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power*

either through the earlier human organization of human beings or “today increasingly through computerization”.¹¹⁶⁷ While an increase in computing power could theoretically allow for a more nuanced reading of a condition or a context, this final step is contingent on the systems manager. In theory, the cyclegraph, like many of the earlier instruments of organization I have discussed in this dissertation, offered the opportunity to more precisely analyze processes in space and time, as well as to simultaneously incorporate feedback into the system. In practice, this sophisticated tool was more often used to describe an ideal scenario rather than engage in trial and error, or even to manage daily production. Already in 1934, Gastev had complained that while “there is hardly another country in the world which produces more chronometric work than ours”, referring to his own workstation scaled chronocyclegraphs, “the majority (of this work) is used for display rather than for analysis.”¹¹⁶⁸ By 1965 *Pravda*, the Soviet Union’s leading newspaper, would make essentially the same critique of the route planning instruments now used throughout Soviet industry, claiming that these projections “frequently became mere forms for the registration of events.”¹¹⁶⁹ Even the most influential Soviet architects shared a similar relationship to this *over-bureaucratized* media as Peter Behrens had had to early industrial plant plans and Gantt charts at the AEG, relegated to working from *programs* developed by a new generation of industrial engineers, employed in massive institutes every five

¹¹⁶⁷ James Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, MA: The Harvard University Press, 1986). For a more detailed account of the connection between management and information technology see Jo Anne Yates, *Control through Communication: The Rise of System in American Management* (Johns Hopkins Press, 1989).

¹¹⁶⁸ Quoted in Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power* 134. The original text is included in Aleksei Gastev, *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda* (Moscow: TsIT, 1966).

¹¹⁶⁹ Quoted in Beissinger, *Scientific Management, Socialist Discipline, and Soviet Power*

years.¹¹⁷⁰ One of the few disciplines allowed the opportunity to manage itself using these tools were Soviet cosmonauts, who used cyclegraphs to manage and document their schedules and routes in space.¹¹⁷¹

The kind of multiplicity of parallel experiments advocated for by Ebenezer Howard in municipal planning, admired by Frank Gilbreth in Germany's DI-Norm program, or imagined, and partially realized, by the RFG's experimental settlements program, was a rarity during the postwar period, not only in the Soviet Union but also throughout much of Europe and in North America. In 1953, "United Nations Report on European Housing Progress" explained that nearly every country in the continent saw increased centralization and mechanization as crucial to addressing the current housing crisis.¹¹⁷² In the United States, the Department of Housing and Urban Development (HUD) initiated "Operation Breakthrough", constructing nearly six thousand units between 1969 and 1974, with the explicit goal of the "industrialization of the building industry" following the Soviet model.¹¹⁷³ Back in 1953, the only European country that claimed to be addressing its own acute housing shortage through a "decentralization of responsibilities for building activity"

¹¹⁷⁰ For a detailed analysis of the organization of the architectural discipline in the Soviet Union, see Colton, *Moscow: Governing the Socialist Metropolis*.

¹¹⁷¹ One of the most widely disseminated examples of a cosmonauts cyclegraph is included in Edward Tufte, *Visual Explanations: Images and Quantities, Evidence and Narrative* (London: Graphics Press, 1997), 94-95.

¹¹⁷² "European Housing Progress and Policies in 1953" 2 (New York: The United Nations, 1954), discussed in "Prefabrication Making Considerable Steps Forward: A United Nations Report," *Prefabrication* 1 No. 12 (October, 1954) 32-34.

¹¹⁷³ The HUD report, E. Jay Howenstine Philip F. Patman, Charles Z. Szczepanski, Jack R. Warner, "Industrialized Building: A Comparative Analysis of European Experience," (Washington D.C.: Department of Housing and Urban Development, 1968), informed Operation Breakthrough. For more on this project see Blaer B. Staats, "Operation Breakthrough: Lessons Learned About Demonstrating New Technology," (Washington D. C.: Comptroller General, 1976), for the official report describing the project, as well as Robert T. McCutcheon, "Science, Technology and the State in the Provision of Low-Income Accommodation: The Case of Industrialized House-Building, 1955-77," *Social Studies of Science* 22, no. 2, Symposium on 'Failed Innovations' (1992). McCutcheon blames the failure of industrialized building in four case studies, the UK, the USA, the Soviet Union and Iran, on the flawed theories of "design professionals", with Le Corbusier being singled out, despite the fact that the HUD report on which Operation Breakthrough was based mentions Le Corbusier only once, in a footnote, and showed little interest in the architect's theories or the American industrial engineers that he had studied.

was Yugoslavia. Overall, this claim was more political propaganda than reality, as Yugoslavia retained the lowest housing standard in Europe for much of the fifties, however, another claim made in 1953, namely that “those responsible (for housing delivery) have shown a more direct interest in making improvements”, due to some actual decentralization initiatives, while itself premature, did describe at least one experiment in *self-managed* housing delivery. This experiment, conducted between 1957 and 1965 by a team of three architects, Bogdan Budimirov, Željko Solar and Dragutin Stilinović, was marked by the restructuring of a failing construction company, Jugomont, into a laboratory following a methodology that drew on the interwar work of Le Corbusier, Gropius and May, as well as the powerful instruments of Soviet routed-settlement building.

From Over-bureaucratization to Self-Management: The Soviet Union and Yugoslavia

In January 1962, Bogdan Budimirov (1928-), director of Jugomont’s Technical Department (TOJ) was sent to Moscow as part of an important Yugoslav delegation with the Soviet Union.¹¹⁷⁴ Although he was still an *absolvent* at the Faculty of Architecture in Zagreb, Budimirov and a group of former classmates had successfully taken over Jugomont, and through a process of trial and error that had lasted four years, developed the JU 61 system of industrialized housing delivery.¹¹⁷⁵ Prior to the month-long visit to Moscow, JU

¹¹⁷⁴ The goal of this delegation was to negotiate an increase in trade between the two countries after a respite in the decade-long tension initiated by Josef Stalin’s 1948 expulsion of Yugoslavia from the COMINTERM.

¹¹⁷⁵ JU 61 was distinctive as one of the few postwar systems to be designed by architects, and not engineers, and as the only locally developed system widely used throughout Yugoslavia. For more on Jugomont and Bogdan Budimirov, see Vladimir Mattioni, “The Ju 61 System of Bogdan Budimirov, Zeljko Solar and Dragutin Stilinovic,” in *Project Zagreb: Transition as Condition, Strategy. Practice*, ed. Ivan Rupnik and Eve Blau (Barcelona: Actar, 2007). Mattioni relates a series of interviews conducted with Budimirov, which are published in their entirety in *Bogdan Budimirov: U Prvom Licu* (Zagreb: upi 2-m, 2007). The majority of the projection instruments used by TOJ are held in Budimirov’s personal archive. Jugomont’s archive was largely lost when the company was absorbed into Industrogradnja in 1975, with the exception of *Jugomont: 1955-1975* (Zagreb: Jugomont/Jugobeton, 1975). My own research on Jugomont has been aided by the extensive documentation held at the Croatian State Archives in Zagreb, particularly boxes 213, 306, 373, 374, 375, 376, 995, 996, 997

61 had existed as an experimental prototype, but had not yet been standardized into a system for large-scale delivery. However, after the visit, Jugomont was able to deliver over 5,000 units, built in Zagreb alone, between 1962 and 1968, due, at least in part, to *technology* imported from the Soviet Union, namely the 1959 manual on routed settlement-building.

The Jugomont construction company formed on December 12, 1954.¹¹⁷⁶ However, between 1955 and 1957, the company struggled to compete for work throughout Yugoslavia, producing only 132 units and barely turning a profit. These obstacles may explain why, starting in 1957, a number of young and inexperienced architects, including Budimirov, Solar and Stilinović, the author's of the JU 61 patent, were able to essentially infiltrate a company run by construction engineers, eventually fill many of the highest positions, including head engineer and design department director, and even invent a new department, the Technical Department (TOJ).¹¹⁷⁷ During their first year, production rose to 375 units, before dropping in 1958 and 1959, a period during which the architects began to develop a new system, later called the JU 60 system and which ultimately led to the gradual development of the JU 61 system.¹¹⁷⁸ While the JU 60 system was a major improvement

and 3380, as well as subsequent interviews with Bogdan Budimirov in 2011 and 2012. The architect's current memory is as impressive as his past work.

¹¹⁷⁶ Jugomont was formed when a "worker's council" of the *Izolit* wood products company voted to branch off, encouraged by new legislation encouraging the decentralization of industry. The council had hoped to develop a prefabricated housing delivery system relying on the company's primary product, *drvolit*, an engineered wood product similar to medium-density fiberboard (MDF).

¹¹⁷⁷ While architects remained a minority, constituting only 15 of nearly one thousand employees, they were placed in key positions in the company during this period.

¹¹⁷⁸ The JU 60 system, which in 1960 resulted in 907 units produced, shifted from an emphasis on complicated multi-layered universal panels, which were primarily produced off-site, to increasingly simplified reinforced concrete panels, organized using an industrialized building approach, which focused on optimizing off and on-site production. Throughout this period, Jugomont competed with other companies for housing commissions from city districts, each with their own budget for constructing subsidized housing. A fixed price per unit was contracted at the outset, and the company that was able to provide the cheapest price was favored for commissions. During this time, there were no Federal, Republic or even municipal

over earlier approaches, building inspectors often found the same problems that plagued all concrete panel housing, namely poor thermal and hydrological performance, in both the panels and their joints. Initially, sheets of corrugated tin were used to repair these problems, but as early as April 1960, the architects began to develop an entirely new approach. By the end of that year, the JU 61 system emerged, which simplified the entire internal structure system into two basic panel types, one vertical and one horizontal panel, and one simple joint detail, executed on-site. (Fig. 235) The most distinctive feature of this system was JU 61's environmental enclosure, a "membrane" of corrugated aluminum, stuffed with mineral wool insulation, glass and fiberglass, leading tenants to nickname the structures *limenke*, or "tin cans". (Fig. 236) Another important innovation of the system was its universal joint detail, patented in 1963. By the time Budimirov left Zagreb for Moscow in early January 1962, both of these details had already been experimentally derived but had not yet been standardized.

Budimirov arrived in Moscow at the peak of the largest industrialized housing delivery project in history, from which 3.5 million square meters of new housing was constructed in 1961 alone. In 1962, the Soviet Union claimed to have constructed 35% of all its housing, 200,000 units, using the *krupnopanel'nyye* (large-panel) system and the Ukrainian SSR claimed as much as 80%, as opposed to 3.5% in Yugoslavia.¹¹⁷⁹ Yugoslavia was not only the least industrialized building industry in Europe, but it was also the least

industrialized housing delivery programs in Yugoslavia. Every Jugomont project was inspected by building inspectors and expected to perform at least as well, and often better, than traditional construction.

¹¹⁷⁹ Soviet satellites, like East Germany, claimed 81%, and Czechoslovakia claimed 40% of their housing was delivered using this highly mechanized approach. While Western European countries had also embraced industrialized housing delivery, the leader, France, whose own large-panel systems had influenced those in the East, could only claim 6%, or 25,000 units, being built according to this method in 1962.

mechanized, as measured by a ratio of tower cranes per thousand units.¹¹⁸⁰ On his tour of Moscow, Budimirov would see over a dozen tower cranes on a single construction site, more than he had seen in all of Zagreb. Additionally, Yugoslavia had the lowest housing standard in all of Europe, averaging 2.35 inhabitants per room in 1953.¹¹⁸¹ The Yugoslav building industry also lacked the centralized governmental coordination in comparison not only to the Soviet Block, but also to western European countries like Sweden, Holland or France.¹¹⁸² The history of Yugoslavia's gradual decentralization and liberalization of a partially implemented command economy, along the Soviet model, between its first postwar constitution, in 1946, and its second "self-management" constitution, in 1963, the peak year of Jugomont's unit production, has not yet been written, but recently declassified CIA documents regarding this process, which the agency referred to as the "Yugoslav Experiment", suggest that many of the initiatives that occurred before 1963 were truly experimental, with the central government spending the next decade deciding what to incorporate into standard practice and what to reject.¹¹⁸³ Jugomont's approach to

¹¹⁸⁰ At its peak, when Jugomont's yearly production reached nearly one thousand units per year, Jugomont had two tower cranes, with a factor barely higher than the average in Bulgaria, the least mechanized Soviet satellite. In contrast, Czechoslovakia had a mechanization of 67, France 62, and the USSR 44, in 1962. East Germany was 'only' 8 times more mechanized than Jugomont, with a factor of 16, reflecting the efficiency, as well as the mechanization, of that countries housing delivery program.

¹¹⁸¹ Yugoslavia's standard was lower than both the USSR (1.7), Poland (1.83) in the east and Greece (2.26) in the south. "To End the Shortage of Housing," in *Central Intelligence Agency Historical Review Program* (Washington DC 1 January 1957). Unfortunately, the housing shortage within Yugoslavia's southern Republics, which held a disparate concentration of industry, was much more acute than in Zagreb, but would not be addressed until the late sixties.

¹¹⁸² In France, the *Ministère de la Construction* coordinated the construction of 5,200 units between 1954 and 1959. The closest equivalent in Yugoslavia was the development of the IMS, or Žeželj system, designed by Branko Žeželj, an engineer who worked for the Construction Institute of Serbia.

¹¹⁸³ It is worth comparing Dennison Rusinow, *The Yugoslav Experiment: 1948-1974* (Berkeley: University of California Press, 1977)., based primarily on evidence provided by the Yugoslav government, which suggests a sense of a planned decentralization process, with the CIA report, "N.I.E. 15-67 the Yugoslav Experiment," (Central Intelligence Agency, 13 April 1967)., declassified in 1994, which portrays the 'Yugoslav Experiment' as a much less controlled process. The CIA's account is much more in tune with the development of JU 61, as documented by the numerous building inspections of JU 61's structures stored in the Croatian State Archives in Zagreb.

industrialized housing delivery therefore benefited from this relatively liberal, often chaotic, governmental policy but it was certainly not the direct result of it. To experiment in this context, Budimirov first needed to reorganize his construction company by installing an organizational system informed by what he saw in the Soviet Union.

As a guest of the Soviet Union in 1962, Budimirov had open access to the myriad of institutes, laboratories and factories participating in the massive industrialized housing delivery effort underway in Moscow. While the young architect was thoroughly impressed with the sheer scale, degree of mechanization, central coordination and professional specialization of the systems he saw, it was precisely those attributes that made him suspicious of the importability of these systems to the Yugoslav context. By this time, the Soviet Union had begun to present gifts to developing countries, in the form of industrial plants, constructed and managed by Soviet experts; as such, it was assumed that Budimirov would also leave Moscow with an agreement for such a gift.¹¹⁸⁴ In 1968, Budimirov would explain his ultimate rejection of the gift of a Soviet panel factory, by comparing it to “having someone from America send you a bus as a gift, but with the stipulation that you drive it to work everyday,” as well as force you to purchase spare parts from them; such a gift “would certainly bring one to financial ruin.”¹¹⁸⁵ Instead, Budimirov chose a smaller, more flexible

¹¹⁸⁴ One of these *gifts*, a prefabricated panel factory given to Chile, was the subject of that country’s Venice Biennale exhibit in 2014. For more on this, see Hugo Palmarola Pedro Alanso, “Monolith Controversies: Pavilion of Chile at the 14th International Architecture Exhibition,” ed. Chile la Biennale Venezia / Council for Culture and the Arts (Ostfildern, Germany: Hatje Cantz, 2014). Ernst May’s Project 14 and JU 61 were both included in this catalog and exhibition.

¹¹⁸⁵ Ljubo Perić Bogdan Budimirov, Željko Solar and Matko Meštrović, “Kako Proizvesti Stan,” [How to Produce An Apartment.] *Dizajn: Časopis za Industrijsko Oblikovanje* I, no. January 1968 Number 7 (1968). A year after Budimirov refused the offer, the Soviet Union donated a panel factory to assist in the rebuilding of the city of Skopje, after the Macedonian capital experienced a devastating 6.9 Richter earthquake on July 26, 1963. Budimirov, who was a member of a committee involved in rebuilding, cautioned against this, but his warnings were not heeded. By 1967 his predictions proved to be correct and in spite of the gift, the panelized housing would cost more to build than other alternatives, ultimately causing the factory to close. In contrast, Jugomont’s own system was applied successfully to two settlements in Skopje.

form of technology, the information technology of scientific management that had now evolved, a half century later, into routed-settlement building. In his tour of the various facilities involved in housing delivery in Moscow, Budimirov had been most impressed with the office of the head *termin-planer*, or “time planner”. For Budimirov, this role was most similar to his own at TOJ, requiring the design and management of the entire delivery system in space and time. The *termin-planer* used two types of projection tools for his work, *tehnologii*, literally translated technology or technological charts, and *tsiklogrammyi*, cyclographs.¹¹⁸⁶ In a 2007 interview, the Yugoslav architect explained that while much of the JU 61 system was developed before the trip to Moscow, “*ciclograms* contributed a great deal” to transforming this single prototype into a system.¹¹⁸⁷

While the Soviet routed settlement-building manuals certainly seemed to have supported the standardization of this experimentally derived system, the system’s development before 1962, as well as the rapidity with which these advanced information management instruments and methods were incorporated into Jugomont’s organizational structure, suggest that the authors of JU 61 were somehow prepared for this task beforehand. For example, Budimirov and his TOJ team established an experimental settlement, specifically for the derivation of standard methods and parameters on May Day, 1962, only three months after the architect had returned from Russia. The construction plant plan of this laboratory, labeled “*organizaciona šema gradilista – šema prometa*” [organization scheme of the construction site – routing scheme](Fig. 237), is in many ways similar to Gropius and May’s earlier work. Here, Budimirov would use the construction of five JU 61 housing slabs to develop a complete routed building drawing set, which would

¹¹⁸⁶ Interview with Bogdan Budimirov, May 24, 2011.

¹¹⁸⁷ Interview with Bogdan Budimirov May 27, 2011.

serve to collect data for later planning, as well as to train his foreman and employees in this new method.¹¹⁸⁸ During this process, Budimirov developed a new type of cyclegraph, one that included both off-site and on-site tasks in a single projection document, as opposed to the instruments presented in the Soviet manuals, which reflected a strict division of labor between the factory and construction. (Fig. 238) This synthesis of off-site and on-site fabrication was paralleled with a more intuitive use of these projection systems, as the Yugoslav architect was able to freehand sketch processes in space and time, in cyclegraphic projection, just as Gilbreth had done with his process charts. It was this more synthetic and intuitive projection process that led to the architectural spatial and tectonic qualities of JU 61, which attracted the attention of architectural periodicals in France and West Germany.¹¹⁸⁹

The comfort with which Budimirov and other architects working at Jugomont approached industrialized housing delivery can be further explained through the common design education they had received from Professor Zdenko Strižić (1902-1990) at the Faculty of Architecture in Zagreb. Strižić's education, work experience during the interwar period, in Germany and France, and extensive professional network, maintained through his affiliation with CIAM, was evident in the architect's design pedagogy.¹¹⁹⁰ His lectures drew on material from Muthesius' *The English House*, the first edition of Le Corbusier's *Oeuvre Complete*, including the complete laboratory work at Pessac, as well as the more

¹¹⁸⁸ Interview with Bogdan Budimirov, 24 May 2011.

¹¹⁸⁹ "Prefabrication En Yugoslavie Procède Ju 61," *l'architecture d'au jourd'hui* 104, no. Habitat (1962). Udo Kultermann, "Suche Nach Neuen Staedten," *Christ und Welt* 8(19.02.1965). Udo Kultermann was introduced to the JU 61 system while attending the third *New Tendencies* meeting in Zagreb. The optical effects of the aluminum and colored fiberglass facades appealed to the optical art aesthetics and programmatic art procedures advocated by that movement.

¹¹⁹⁰ Eric Mumford, *The Ciam Discourse on Urbanism, 1928-1960* (Cambridge: The MIT Press, 2002). Strižić's lectures were published in two books, Zdenko Strižić, *Arhitektonsko Projektiranje I* (Zagreb: University of Zagreb, 1952). and *Arhitektonsko Projektiranje II: O Stanovanju* (Zagreb: University of Zagreb, 1956).

recent work of Jean Prouve in prefabrication, during the peak of the Cold War. During the first two years of their education, Jugomont's future architects learned about "drawings for conventional construction," which "always show a completed object," and drawings for prefabrication, which often visualize "various phases of construction."¹¹⁹¹ Strižić combined an interest with industrialization with a critical stance toward the potential "transformation of the architect into a specialist of industrially produced houses," fearing that this would lead to "the loss of his ability to see the big picture and [lead] to [the] evaluation of an object only from the viewpoint of fabrication," and not of dwelling. He also offered his pupils a more territorial view of industrialized housing delivery, offering conceptual diagrams of decentralized and centralized networks of material resources, production facilities, and building sites.¹¹⁹² (Fig. 239) It was this conceptual outlook that helped Budimirov organize his own network of material distribution and component production, one that took advantage of Croatia's ample bauxite reserves, Slovenia's skilled craft labor and Serbia's mass production facilities. Cyclegraphs optimized this network, but it was already in place prior to 1962.¹¹⁹³ Strižić's pedagogy had drawn on the earlier disciplinary knowledge of the interwar period, which had been informed by the principles of scientific management as translated through the laboratories and experimental settlements of the twenties. This intellectual foundation was common to the Jugomont team as well as to their collaborators in other municipal institutions, such as the building

¹¹⁹¹ *Arhitektonsko Projektiranje I*.

¹¹⁹² These diagrams were similar to those included by Le Corbusier in 1950 in order to explain the reasoning behind the Unité's constructive logic, one that combined site cast concrete frames with prefabricated concrete and steel components, which would be made in more centralized workshops, similar to Prouve's Maxville facility, near Nancy. Le Corbusier, *The Marseilles Block* [L'unité d'habitation de Marseille], trans. Geoffrey Sainsbury (London: The Harvill Press, 1953 (1950)).

¹¹⁹³ Strizic, *Arhitektonsko Projektiranje I*, 94-96. Željko Solar was Strižić's teaching assistant and Bogdan Budimirov was a *demonstrator*. Strižić's mappings of material and methods in space and time resemble the drawings Le Corbusier used to explain the *unité d'habitation*. See Corbusier, *The Marseilles Block*, 50.

inspections or city planning offices.¹¹⁹⁴ At this time, Budimirov and his colleagues also had access to some of the instruments and methods developed by the RFG, which had been summarized in Ernst Neufert's second manual, *Bauordnungslehre* (1943), (Fig. 240) and translated into Serbo-Croatian by Vladimir Potočnjak, a student of Adolf Loos' and Ernst May's in 1952.¹¹⁹⁵ Access to this manual, and through it, to the work of the RFG, helps explain a number of other key projection instruments developed by Budimirov immediately prior to his trip to Moscow, such as his "Šema Montaže", essentially a packet plan that carefully arranged the position of panels on site so as to inform the motions of one of Jugomont's few cranes.¹¹⁹⁶ (Fig. 241)

The open ended process of experimentation and standardization practiced by Budimirov and his colleagues came to an abrupt end in 1964, due primarily to complaints from the middle management, the company's construction foreman, for whom this approach seemed unnecessary. They would use the same, still loosely defined, ideology of "self-management", which Budimirov and Solar had used to justify their reorganization of the company, to push these architects out of it, preferring instead to purchase already standardized building systems from abroad. In 1966, Budimirov would close the loop started by Ernst May, moving to West Germany where, due to his extensive experience in *practical experiments*, he was perceived as an expert in systems thinking, and collaborated

¹¹⁹⁴ Mirko Maretić, one of the architects in charge of Zagreb's general urban plan during this period carried a 1930 edition of Unwin's *Town Planning in Practice*.

¹¹⁹⁵ Ernst Neufert, *Bauordnungslehre* (Berlin: Volk und Reich Verlag, 1943). Adolf Hitler, like Josef Stalin, considered American industrial engineering a foreign import and therefore banned it, only bringing it back to assist in the construction of factories during the war. Ernst Neufert had worked for Walter Gropius and later, directly for the RFG. After 1933, he was one of the few RFG participants to have remained in Germany. For more on Neufert see Gernot Weckherlin, "Ernst Neufert's Architects' Data: Anxiety, Creativity and Authorial Abdication," in *Architecture and Authorship*, ed. Katja Grillner and Rolf Hughes Tim Anstey (London: Black Dog, 2007), 148-55.

¹¹⁹⁶

with Werner Wirsing (1919-) a German architect who also taught at the *Hochschule für Gestaltung* in Ulm, which was seen by many as the postwar equivalent of the Bauhaus. Wirsing had learned of Budimirov's work through other colleagues at Ulm, a number of who had participated in a series of conferences held in Zagreb, between 1961 and 1972, as part of the New Tendencies movement. The key participants of these events, including Umberto Eco, Abraham Moles and Tomas Maldonado, came together in Zagreb to discuss a set of common interests in what was first referred to as *arte programatta*, or "programmed art", in 1962, and what would evolve into an early critical assessment of the role of the computer in artistic, as well as architectural and urban, production. Matko Meštrović, a Croatian art critic and theorist and one of the key initiators of these conferences, wrote extensively on the JU 61 system, presenting Jugomont's *programs* and multi-sensory environments of reflective aluminum, colored polyester and glass to these visitors, who ultimately found this mode of architectural production and spatial experience closely aligned with their own theories.¹¹⁹⁷ (Fig. 242)

¹¹⁹⁷ For more on the New Tendencies movement see Margit Rosen, ed. *A Little-Known Story About a Movement, a Magazine, and the Computer's Arrival in Art: New Tendencies and Bit International, 1961--1973* (Cambridge: The MIT Press, 2011). Bogdan Budimirov apprenticed with the only architect to participate in all of the New Tendencies conferences, Vjenceslav Richter. Between 1963 and 1968, Richter developed a programmed architecture, while "waiting for the computer", as explained in Vjenceslav Richter, "Dilemma," *BIT International* 3(1968). The following year, another member of the NT movement, Vladimir Bonačić (1938-1999), installed digital façades onto two of Zagreb's self-managed department stores. Bonačić later moved to Israel, where he taught at the Technion – Israel Institute of Technology.

Chapter 1: Figures



Fig. 01. Photograph of Frank Gilbreth, Frederick Taylor, Henry Gantt and Carl Barth inspecting Gilbreth's motion study laboratory at N.E. Butt. Co., in Providence, RI, where the experimental derivation of standard methods took place. February 13, 1913.

Source: "FLGA Box 146 Photographs, Undated Folder 0021. image 200.156"

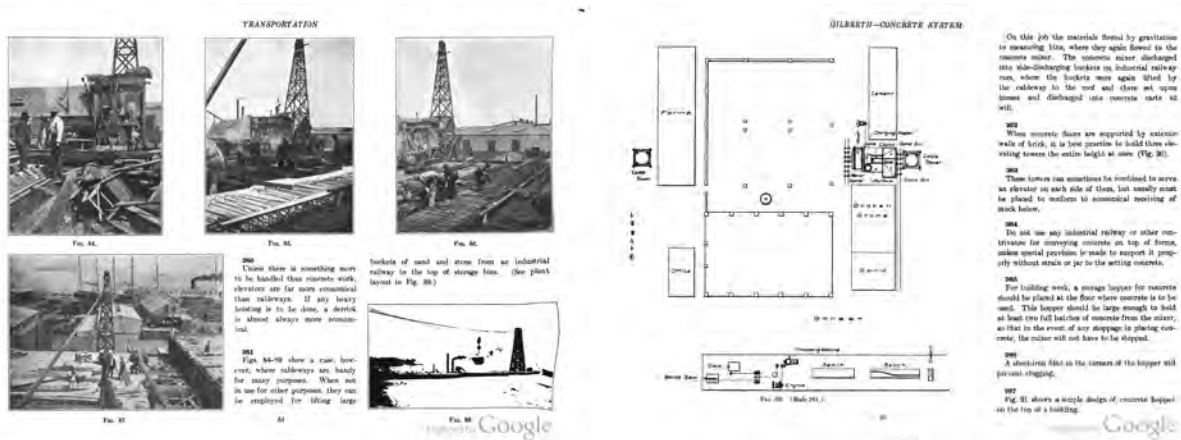


Fig. 2. Spread from Frank Gilbreth, *Concrete System*, showing the standardization of construction motions at a temporary construction plant in San Francisco, CA, circa 1905.

Source: Gilbreth, Frank Bunker. *Concrete System*. New York: The Engineer News, 1908. 51-52.

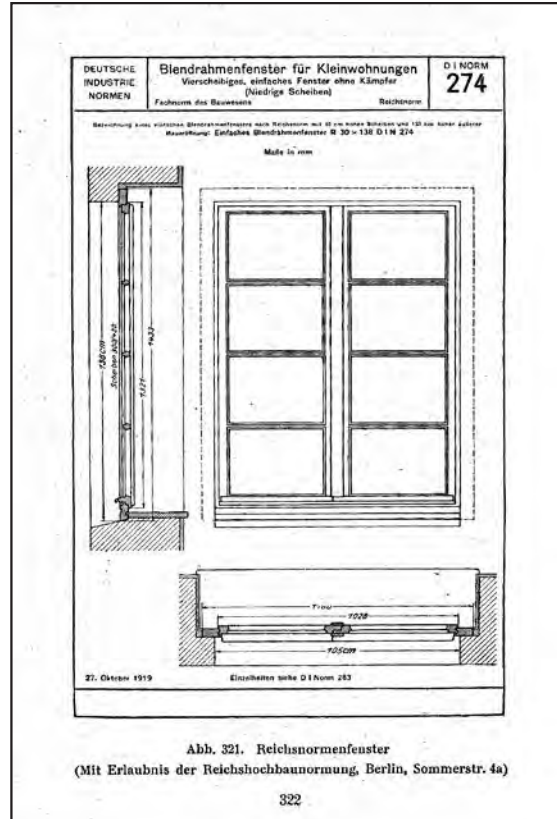


Fig. 3. Page from *Kleinhaus und Kleinseidlung* (1918), showing “typification work” by Hermann Muthesius (left) and page from *K und K* (1920), showing D I Norm 274 for a window (right).

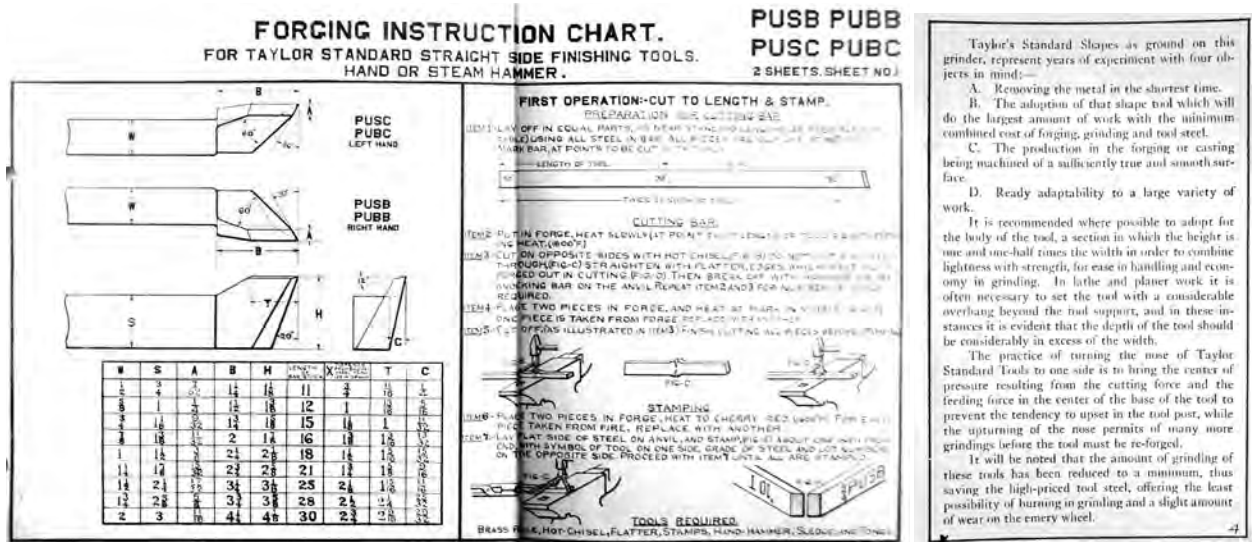
Source: Muthesius, Hermann. *Kleinhaus und Kleinsiedlung*. Munich: F. Bruckmann, 1918. 226; Ibid. 1920. 322.



Fig. 4. Spread from Le Corbusier, “Eyes That Do Not See... III: Automobiles” (1920) showing established standards and standardized forms in Hellenic Temple architecture and French automobiles.

Source: Corbusier, Le. “Des Yeux Qui Ne Violent Pas... Iii: Les Autos.” *L'Esprit Nouveau* 10 (1920): 1140-41.

Chapter 2: Figures



Taylor's Standard Slopes as ground on this grinder, represent years of experiment with four objects in mind:—

- Removing the metal in the shortest time.
- The adoption of that slope tool which will do the largest amount of work with the minimum combined cost of forging, grinding and tool steel.
- The production in the forging or casting being machined of a sufficiently true and smooth surface.
- Ready adaptability to a large variety of work.

It is recommended where possible to adopt for the body of the tool, a section in which the height is one and one-half times the width in order to combine lightness with strength, for ease in handling and economy in grinding. In lathe and planer work it is often necessary to set the tool with a considerable overhang beyond the tool support, and in these instances it is evident that the depth of the tool should be considerably in excess of the width.

The practice of turning the nose of Taylor Standard Tools to one side is to bring the center of pressure resulting from the cutting force and the feeding force in the center of the base of the tool to prevent the tendency to upset in the tool post, while the upturning of the nose permits of many more grindings before the tool must be re-forged.

It will be noted that the amount of grinding of these tools has been reduced to a minimum, thus saving the high-priced tool steel, offering the least possibility of burning in grinding and a slight amount of wear on the emery wheel.

Fig. 7. Pages from Frederick Taylor's Forging Instruction Chart. For Taylor Standard Straight Side Finishing Tools. Hand or Steam Hammer, 1907.
Source: FLGA, Box 44 Fatigue Study and Industrial Management, Ca. 1915-1934. Folder 0286-1 - Taylor Tools.

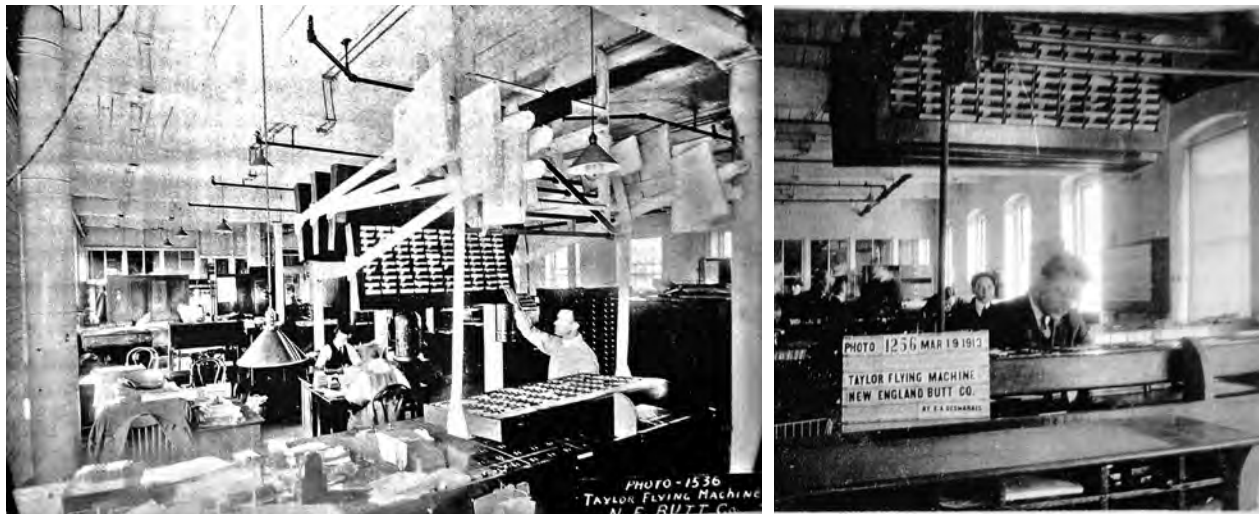


Fig. 8 Frank Gilbreth, photograph (left) and progress photo (right) of Taylor Flying Machine in use at the planning department of the NE Butt Co., Providence, RI, 1913.
Source: Flga Box 11 Photographs of Various Studies 1909-1914. Folder 0031-4 - Ne Butt Co- 1913. Photos 1536, 1256.

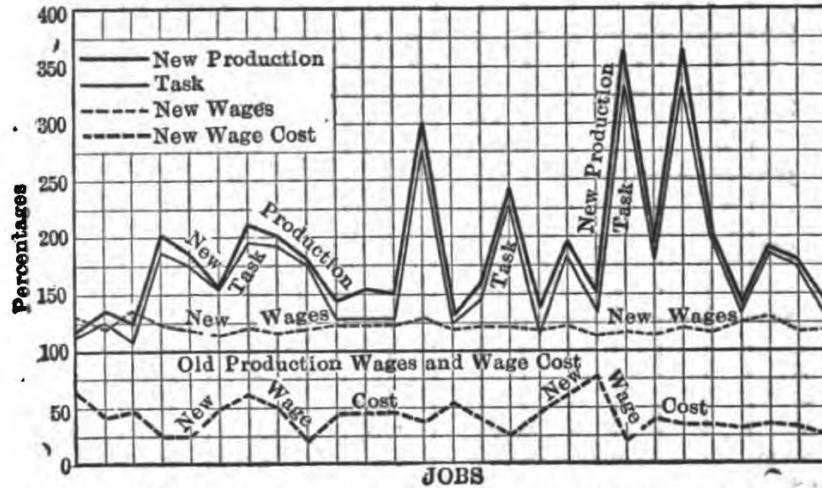


CHART XV. WAGES AND PRODUCTION DIAGRAM ON SMALL AUTOMATIC SCREW-MACHINE WORK

Bild 19.

A. E. G.

- Rohmaterial
- Halbfabrikate
- Anlagen in Arbeit
- fertige Fabrikate

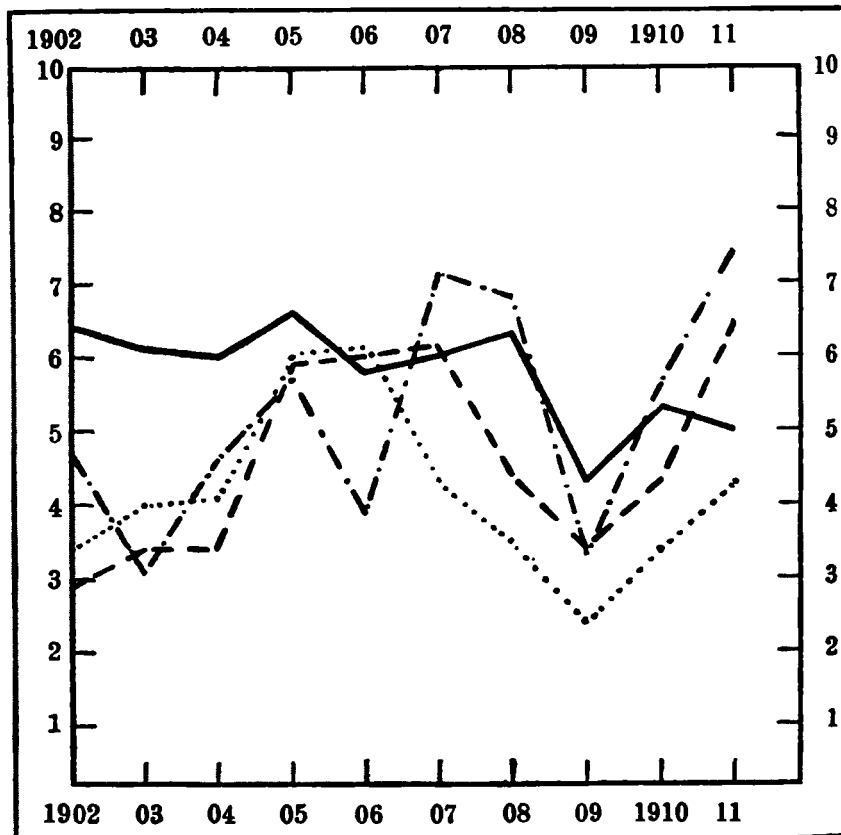


Fig. 9. Plate from *Work, Wages Profits* (1913) showing line graph of wages and production (left) and plate from Niklisch, *Wirtschaftliche Betriebslehre* [Systematic Management Theory] (1912) (left) showing line graph of production and costs at the AEG, between 1902 and 1911 (right).

Source: *Work, Wages and Profits*. 213; Nicklisch, Heinrich. *Wirtschaftliche Betriebslehre*. 6 ed. Stuttgart: C. E. Poeschel, 1922 (1912). 218.

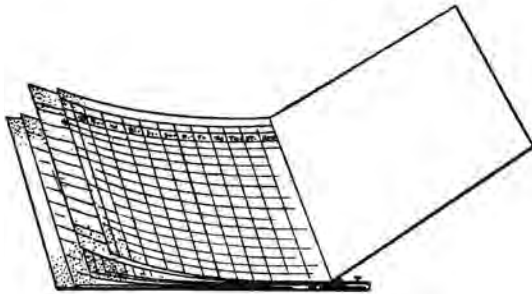


FIGURE 4. BINDER FOR CHARTS

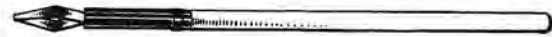


FIGURE 6. LETTERING PEN USED FOR MAKING GANTT CHARTS

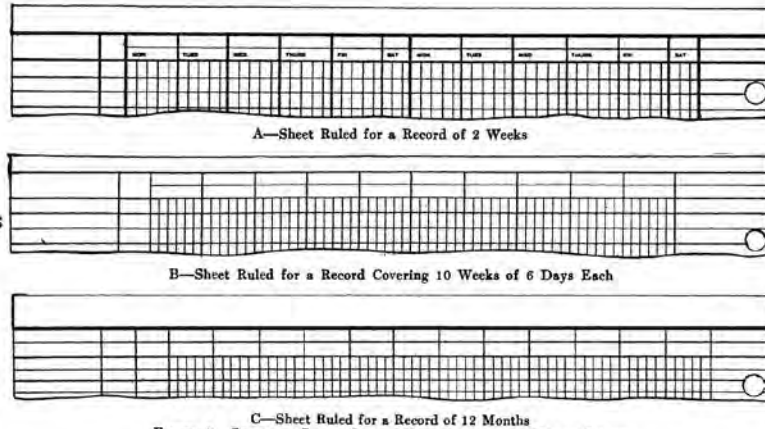


FIGURE 5. STANDARD RULED SHEETS USED IN PLOTTING GANTT CHARTS

FIGURE 7. A GANTT MACHINE RECORD CHART

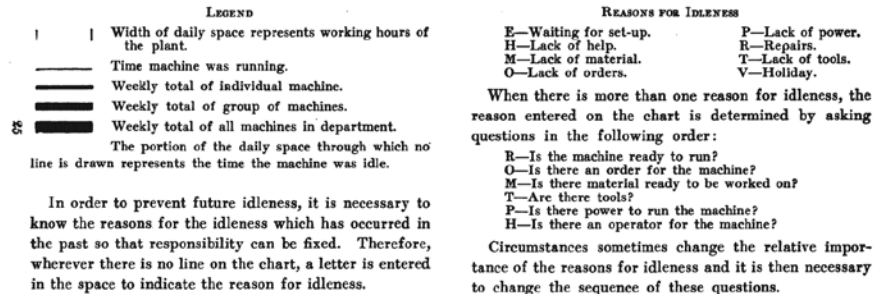


FIGURE 11. A GANTT MAN RECORD CHART

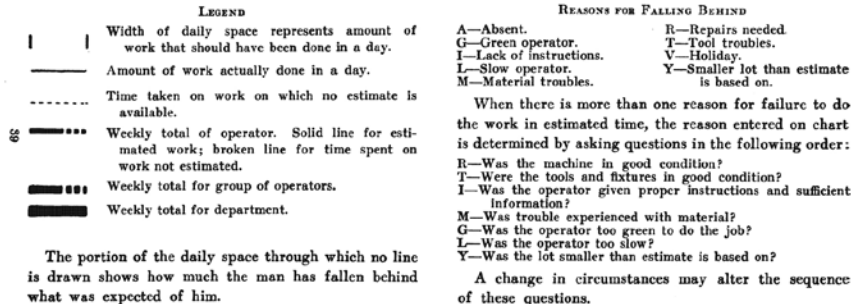


Fig. 10. Plates showing binder for (Gantt) charts, lettering pen used for making Gantt charts, Gantt chart sheets ruled for 2 weeks, 10 weeks and 12 months, parameters for making a Gantt machine record chart and a Gantt man record chart, from Clark, *The Gantt Chart* (1922).

Source: Clark, Wallace. *The Gantt Chart: A Working Tool of Management*. New York: The Ronald Press Company, 1922. 10, 15, 12, 25, 39.

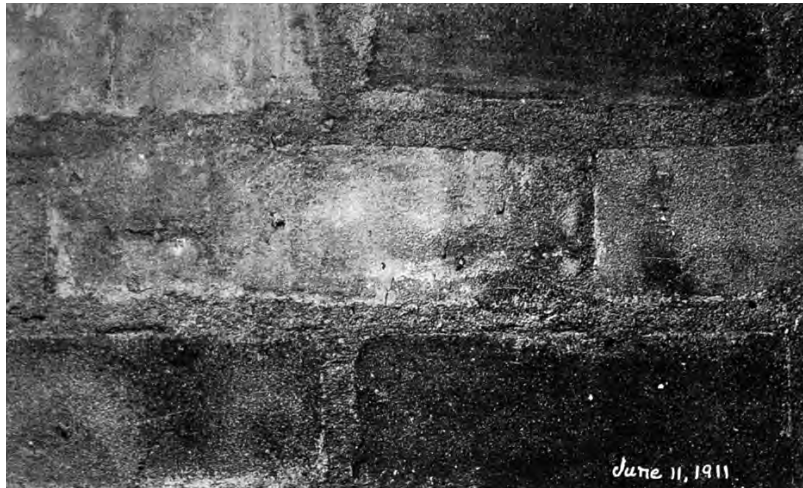


Fig. 11. Photographs of Parthenon (Frank Gilbreth in foreground), Pompeii, from 1907, of a brick wall behind Boston's State House, June 11, 1911, and of Frank Gilbreth (furthers right) and his camera at a meeting with the board of directors of Auer in Berlin, in May 1914.
Source: FLGA Box 146 Photographs, Undated Folder 0028 V. II 2; FLGA Box 12 Folder 0031-21 Chronocycle-
graphs; FLGA Box 149 Photographs, Ca. 1914 and Undated Folder 0031-8 Germany 1914.

FRANK B. GILBRETH (INC) SYMBOL

INSTRUCTION CARD FOR OPERATION

SHEETS, SHEET No. 1 MACHINE No. _____ ORDER No. _____

DESCRIPTION OF OPERATION **FOLDING HANDKERCHIEFS.**
10x10 FOLD
12" BEFORE FOLD

HAND NOT IN MOTION SYNTHESIZED TIMES

ITEM	DETAILED INSTRUCTIONS		ELEMENT TIME PER SECOND	TIME FOR ENTIRE LOT	CONTINUOUS OR RUNNING TIME		
	LEFT HAND	RIGHT HAND					
	SCALE $\frac{1}{10}'' = \frac{1}{1000} \text{ MIN.}$						
	HELD READY TO RECEIVE HE.	REACH FOR HE. AT RIGHT		.24			
	PICK UP LEFT EDGE	BRING TOWARDS BOARD		.24			
	DRAW TO BOARD	FOLLOW LEFT HAND		.18			
	ADJUST TO EDGE AND BEGIN FOLD	ADJUST TO EDGE AND BEGIN FOLD		.18			
	FIRST FOLD UP	FIRST FOLD UP		.24			
	HOLD DOWN LEFT EDGE	CREASE		.42			
	FOLD DOWN TO GUIDE	ON LINE OF FOLD		.36			
	CREASE	CREASE		.36			
	HOLD LEFT EDGE	PICK UP RIGHT EDGE		.18			
	HELD TO RECEIVE FOLD	FOLD TO LEFT		.30			
	TWIST 90° CLOCKWISE	TWIST 90° CLOCKWISE		.18			
	FOLD DOWN TO GUIDE	FOLD DOWN TO GUIDE		.42			
	CREASE	CREASE		.36			
	PICK UP	PICK UP		.24			
	PLACE IN BOX IN FRONT	PLACE IN BOX IN FRONT		.49			
73 THOUS. MIN.				4.39 SEC.			
L. M. G. CHUTE							
<input type="checkbox"/> FOLDED HFS. <input type="checkbox"/> FOLDING BOARD <input type="checkbox"/> UNFOLDED HFS <input type="checkbox"/> FOLDER							
WHEN INSTRUCTIONS CANNOT BE CARRIED OUT FOREMAN MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD				MONTH	DAY	YEAR	SIGNATURE
				11	27	13	<i>Stonck</i>

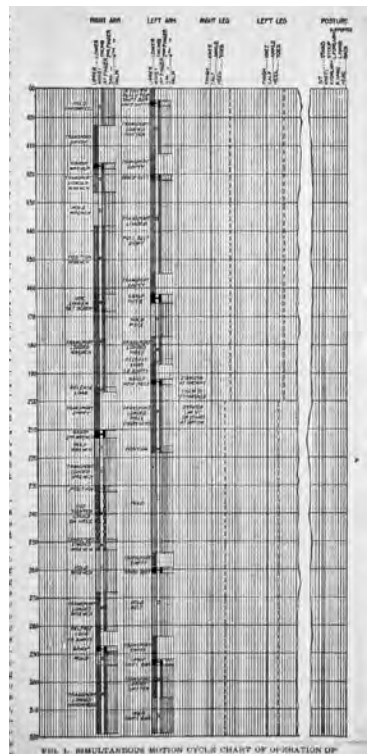


Fig. 12. Frank B. Gilbreth, Instruction Card for Operation: Folding Handkerchiefs, Hermann Aukam Co., South River, NJ (left), plate from F. Gilbreth, *Bricklaying* (1909), showing micromotion studies of bricklaying (top right), and plate from F. Gilbreth, "Methods of Analyzing Motions by Graphical Charts" (1916), showing a simultaneous motion cycle chart of operation of chucking work. Sources: FLGA Box 163 Photographs, Ca. 1912-1921 Folder 0411 1913 [Graphs with Micromotion Strips on Handkerchief Folding]; *Bricklaying System*. New York: Myron C. Clark Publishing, 1909. 145; "Methods of Analyzing Motions by Graphical Charts." *American Machinist* 45, no. 6 (1916).

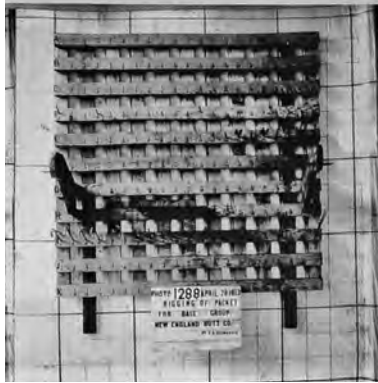


Fig. 13. Frank Gilbreth, photographs of rigging of packet for base group, the Littlefield Johnson packet and skilled motions, assisted by pacjet (Gilbreth, right) at NE Butt Co., 1913 (top) and spread from "Micro-Motion Study: A New Development in the Art of Time Study" (1913) (bottom).

Sources: FLGA Box 34 Industrial Management - Control and Job Classification, 1912-1921 Folder 0956 0247 - packet method 1915-19 Photos 1288 and 1243; FLGA Box 11 Photographs of Various Studies 1909-1914. Folder 0031-4 - NE Butt Co- 1913 Photo 610-267; "Micro-Motion Study: A New Development in the Art of Time Study." Industrial Engineering and the Engineering Digest XIII, no. 1 (January, 1913): 1-4.



Fig. 14. Frank Gilbreth, photograph of workmen watching micromotion study films, NE Butt Co., Providence, RI, 1913.

Source: FLGA Box 50 Photographs and Motion Study, ca. 1912-1931 Folder 0299-12 Photo 610-282

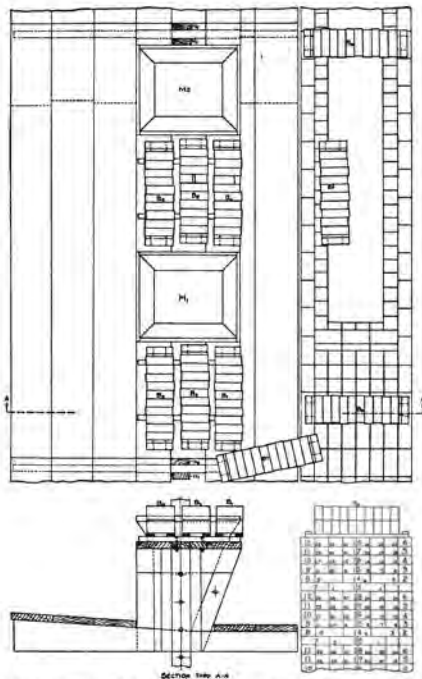


Fig. 66.—Location of Pads for Shortening Distance of Transporting Brick to Wall.

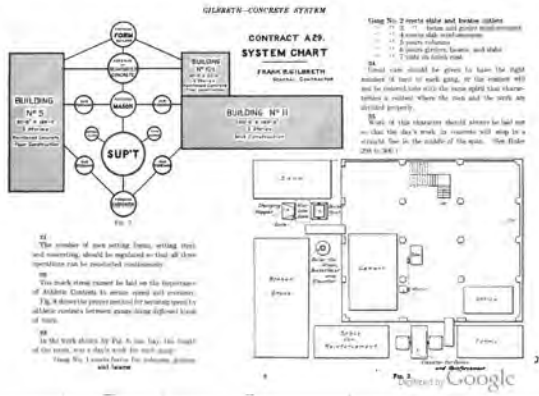


Fig. 7
The number of men working on any one job, and the number of men working on any one job, should be specified so that all the operators can be produced consistently.

Fig. 8
The work should be laid on the department of labor. Existing to some extent with previous.

Fig. 9
The work should be laid on the department of labor. Existing to some extent with previous.

Fig. 10
The work should be laid on the department of labor. Existing to some extent with previous.

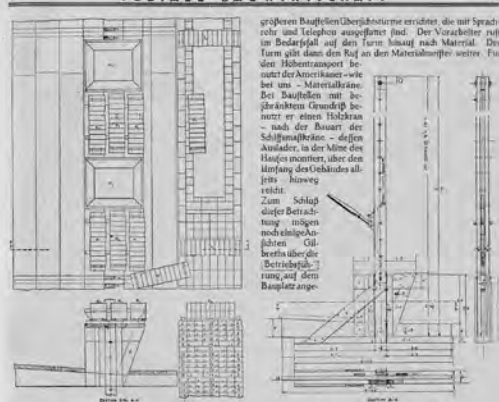


Abb. 6. Verbindung der Mauerblöcke von Gipsputzwerkern auf dem Gipsputzwerk.

größeren Baustellenüberbauten erreicht die mit Spritzrohr und Telephon ausgestattet sind. Der Vorarbeiter ruft im Bedarfplan auf den fürn Bauort nach Material. Der Mann gibt dann das Maß an dem Materialbehälter weiter. Für den Materialtransport bezieht der Arbeiter seine Arbeit bei uns - Materialkranne. Bei Baustellen mit begrenztem Grundbesitz bezieht er einen Holzkrane - nach der Bauart der Schiffsmaße - dessen Ausleger, in der Höhe des Hauses montiert, über den Umfang des Gebäudes allseitig hinweg reicht. Zum Schluss dieser Betrachtung mögen noch einige wichtige Punkte über die Betriebsführung, auf dem Bauplatz ange-

Abb. 7. Umrüstung, Arbeit mit Vorarbeiten der Überbauarbeiten.

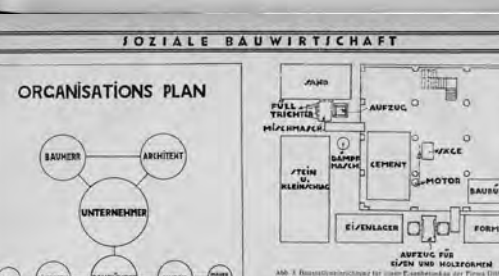


Abb. 1. Organisationsplan für das Bauteil der Firma F. B. Gilbreth.

achten, daß jeder Arbeitstag die richtige Zahl von Arbeitern besitzt. Auf kleineren Baustellen ist eine andere Einteilung der Arbeit erforderlich. Z. B.: lasse zunächst alle Einschaltungen vom Zimmermann herstellen und stelle diese Leute dann an eine andere Arbeit, wenn die Einschaltungen fertig sind. Dann lasse das Flechtwerk in einem Umfang herstellen, der die Betonarbeiten für einige Tage sichergestellt. Dann erst beginne mit dem Betonstampfen und lasse die Zimmerleute die Einschaltungsarbeiten fortsetzen. Diese Methode ist in Großstädten leichter durchführbar



Abb. 4. Auf einer Tagelohnarbeit an verschiedenen Arbeitsplätzen für die Eisenbetonwerke.

Abb. 5. Eine Eisenbetonkonstruktion für einen Eisenbetonbauwerk.

Fig. 15. Spreads from F. Gilbreth's *Bricklaying System* (1909) and *Concrete System* (1908) (left) and from Martin Wagner's journal, *Soziale Bauwirtschaft* (1921, 1925) (right).
 Source: F. Gilbreth, *Bricklaying System*. New York: Myron C. Clark Publishing, 1909. 80; F. Gilbreth, *Concrete System*. New York: The Engineer News, 1908. 8; M. Wagner, "Wirtschaftliche Betriebsführung Im Baugewerbe." *Soziale Bauwirtschaft* 1, no. 7 (1 April 1921): 79-84; M. Wagner, "Wie Ein Amerikanischer Bauunternehmer Die Wirtschaftliche Betriebsführung Fördert." *Soziale Bauwirtschaft* 5, no. 3 (1 February 1925): 25-28.

GENERAL RULES

- 1 A copy of this *Field System* must be kept in the office on each job.
- 2 Address all communications to *Frank B. Gilbreth*, and not to any other name. They will then be attended to promptly and not treated as personal mail.
- 3 Notify office of accidents at once by telephone or telegraph if accident is serious. Accident blanks must be filled out, the original mailed to insurance company's agent, and the duplicate to New York Office at once.
- 4 Sign "received," with name and date on the back of all plans, details, drawings or sketches (stamp in the middle of the plan if possible), regardless of where or from whom the plans are received. This will prevent the substitution of blueprints from altered tracings.
- 5 Provide every convenience for Owners or Officials who inspect your work.
- 6 To prevent confusion, Superintendents must do business through the Architect or Engineer—not with the Owner direct.
- 7 Estimates are not to be given by anyone, at any time, without first consulting the Office.

GILBRETH—CONCRETE SYSTEM

CHAPTER II.—GENERAL RULES

- 1 In the absence of any plans, specifications, or instructions to the contrary from our office, these rules must be carried out to the letter.
- 2 We have never had any concrete work fall down, and we never will have if the rules in this System are carried out. If we are obliged to do work in a different way from that which we believe to be the best way, we must protect ourselves by getting our views on record in writing.
- 3 If you receive orders from the owner, architect, or engineer that are contrary to any of these rules, you must notify our office of their wishes and request them to give their orders to you through our office. We are then able to put our protests on record, in writing, at the time we proceed in accordance with their orders.
- 4 Field work must be under the general supervision of the Main Office.
- 5 Field office, engine house, tool houses and all temporary buildings should wherever possible be built and equipped according to standard designs on file at the office.
- 6 The "Field System" shall govern any matters not covered by this System, such as accounting, receipt of materials, general orders, manifold hooks, and all other matters not pertaining to concrete.
- 7 Employees must not alter or change an architect's or engineer's plans or specifications under any conditions whatever.
- 8 Employees must not discuss an architect's or engineer's plans with any one except members of our organization.
- 9 No employee is permitted to leave anything whatsoever to do with any job where there is not an architect or engineer employed by the owner.
- 10 (We have never deviated from this rule in the past, and shall not permit any violations of this rule in the future.)
- 11 The superintendent must be on the work during regular working hours, and at such other times as may be necessary.
- 12 When starting a new job, the superintendent shall have a line diagram made on tracing cloth, showing general layout of work, posts, girders, beams, panels, etc., and shall send a blueprint of same to Main Office daily with Daily Letter, after having indicated thereon the amount of work accomplished, and what athletic contests (see Field System, page 17) have been carried out that day. Consult Main Office for instructions regarding method of marking up these blueprints.
- 13 Superintendents shall make up and send into the office a sketch of a plant and equipment layout, and also a system chart showing which men they recommend for assistants on their job. The office will return these to the job as soon as revised and approved.
- 14 A few sample charts showing layouts and routes of authority as submitted and approved are given on the following pages (see Figs. 1-7) to show superintendents what is expected of them.
- 15 The superintendent must take enough photographs to keep the office in perfect touch with his job. See "Field System," Rules 90 to 122, concerning photography.
- 16 Superintendents must put all matters of importance on record in the Daily Letter. Records often prevent misunderstandings and lawsuits.
- 17 Superintendents must so conduct their work that they will receive letters from the owner similar to the following:

Dear Sir:

I have the honor to inform you that the Lowell Laboratory of Electrical Engineering, which you have built during the past summer, has been today inspected by the committee and accepted. I wish to express to you, at the same time, the thanks of the Executive Committee and of the Building Committee for the promptness, efficiency and skill with which the work has been carried through.

Yours very sincerely,
Frank B. Gilbreth
President

October 20, 1908

Fig. 16. Frank Gilbreth, pages from *Field System* (1908) and *Concrete System* (1908) showing tentative standard protocols or "general rules", similar to instruction card subtasks, as shown in Fig. 06. Sources: F. Gilbreth, *Field System*. New York: Myron C. Clark Publishing, 1909. 21; F. Gilbreth, *Concrete System*. New York: The Engineer News, 1908. 6.

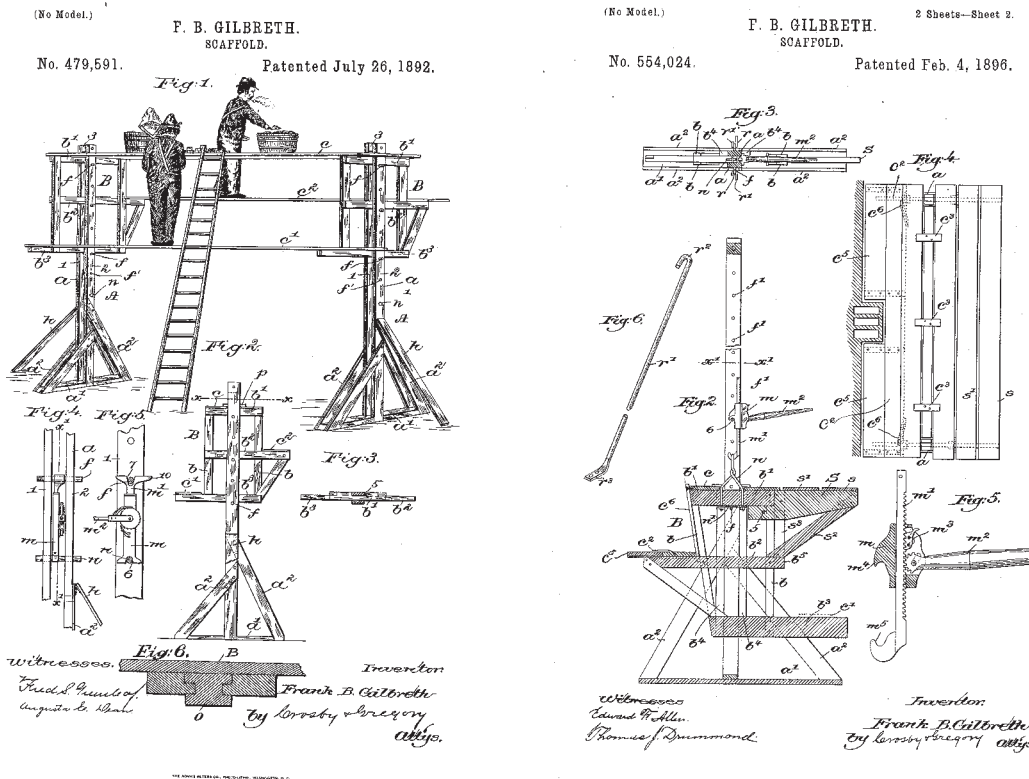


Fig. 17. Frank Gilbreth, patents for scaffolds from July 26, 1892 and February 4, 1896. Sources: F. Gilbreth US Patent 479,591; F. Gilbreth US Patent 554,024.

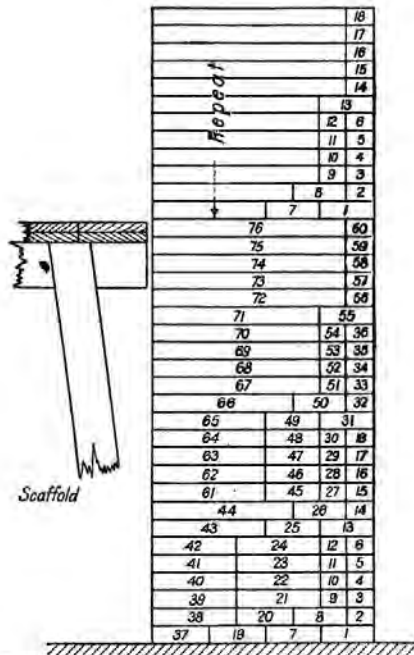


Fig. 46.—Sequence in Which Courses and Tiers are Built Overhand from a

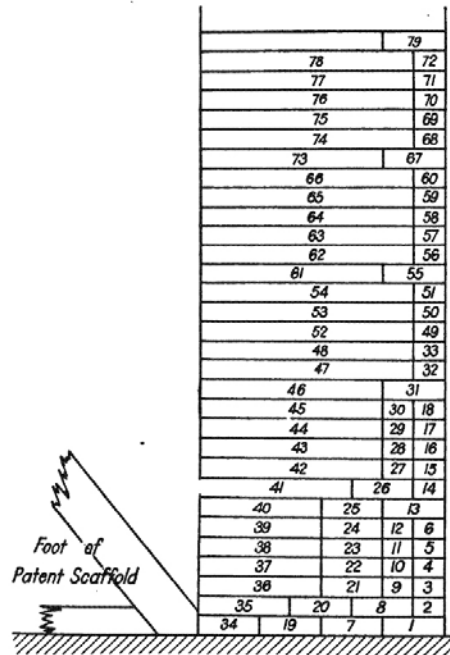


Fig. 47.—Sequence in Which Courses and Tiers are Built Overhand from the Gilbreth Scaffold, Hod Type.

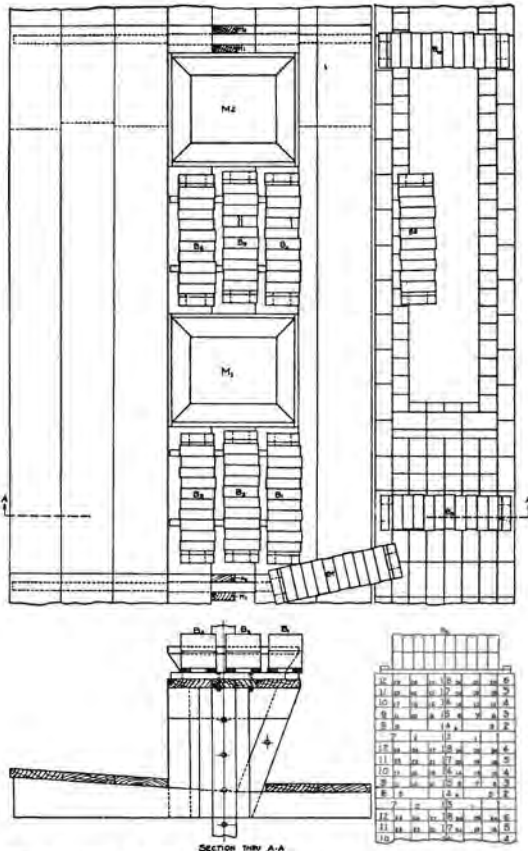


Fig. 66.—Location of Packs for Shortening Distance of Transporting Brick to Wall.

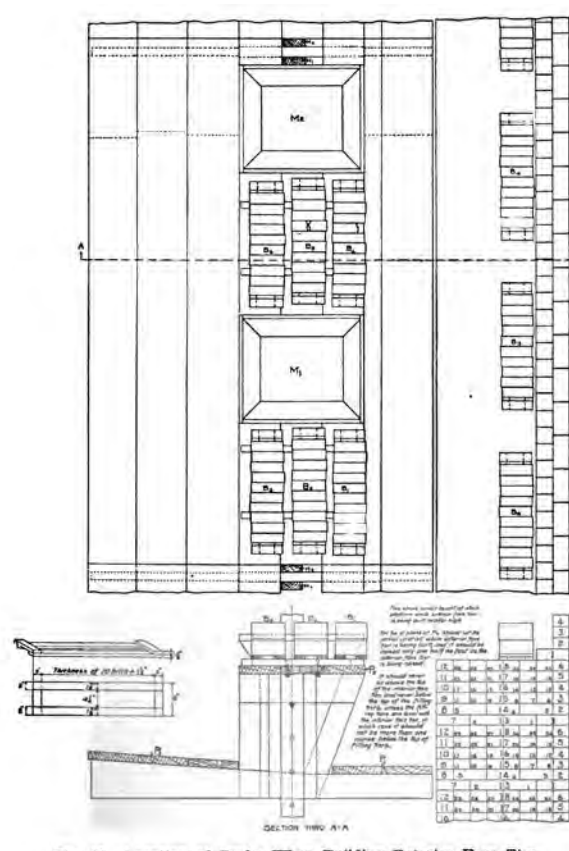


Fig. 68.—Location of Packs When Building Exterior Face Tier.

Fig. 18. Plates from F. Gilbreth, *Bricklaying System* (1909) comparing the organizational logics and spatial and temporal sequences of a conventional trestle horse scaffold and a Gilbreth hod type scaffold (top) and plans and sections of Gilbreth scaffold organized for general brick courses and exterior face brick (bottom). Source: F. Gilbreth, *Bricklaying System*. New York: Myron C. Clark Publishing, 1909. 60, 61, 80, 83.



Fig. 19. F. Gilbreth, progress photos of Gilbreth scaffold, installed on a construction site in Boston, MA, July 1911.
Source: FLGA Box 146 Photographs, undated Folder 0028 v. II 2 bricklaying and factory studies Photos 603-30, 603-76.

Operation No.	The Wrong Way.	The Right Way.	PICK AND DIP METHOD. THE EXTERIOR 4 INCHES (LAYING TO THE LINE).
	Motions per Brick.	Motions per Brick.	
1	Step for Mortar.	Omit.	On the scaffold the inside edge of mortar box should be plumb with inside edge of stock platform.
2	Reaching for Mortar.	↓	On floor the inside edge of mortar box should be 21 in. from wall. Mortar boxes never over 4 ft. apart. Do not bend any more than absolutely necessary to reach mortar with a straight arm.
3	Working up Mortar.	Omit.	Provide mortar of right consistency. Examine sand screen and keep in repair so that no pebbles can get through. Keep tender on scaffold to temper up and keep mortar worked up right.
4	Step for Brick.	Omit.	If tubs are kept 4 ft. apart no stepping for brick will be necessary on scaffold.
5	Reach for Brick.	Included in 2.	On floor keep brick in a pile not nearer than 1 ft. nor more than 4 ft. 6 ins. from wall.
6	Pick up Right Brick.	Omit.	Brick must be reached for at the same time that the mortar is reached for, and picked up at exactly the same time the mortar is picked up. If it is not picked up at the same time, allowance must be made for operation.
7	Mortar, Box to Wall.	↓	Train the leader of the tenders to vary the kind of brick used as much as possible to suit the conditions; that is, to bring the best brick when the men are working on the line.
8	Brick, Pile to Wall.	Included in 7.	Carry stock from the staging to the wall in the straightest possible line and with an even speed, without pause or hitch. It is important to move the stock with an even speed and not by quick jerks.
9	Deposit Mortar on Wall.	Included in 7.	Brick must be carried from pile to wall at exactly same time as the mortar is carried to the wall, without pause or jerk.
10	Spreading Mortar.	Omit.	If a pause is made, this space must be filled out. If no pause is made it is included in No. 7.
11	Cutting off Mortar.	Omit.	The mortar must be thrown so as to require no additional spreading and so that the mortar runs up on the end of the previous brick laid, or else the next two spaces must be filled out.
12	Disposing of Mortar.	Omit.	If the mortar is thrown from the trowel properly no spreading and no cutting is necessary.
13	Laying Brick on Mortar.	↓	If mortar is not cut off, this space is not filled out. If mortar is cut off keep it on trowel and carry back on trowel to box, or else butter on end of brick. Do not throw it on mortar box.
14	Cutting off Mortar.	Every 2nd brk ↓	Fill out this space if brick is held still while mortar is thrown on wall. When brick is laid on mortar it presses mortar out of joints: cut this off only at every second brick. It takes no longer to cut mortar off two bricks than one.
15	Disposing of Mortar.	Butter ↓ End Joint.	When this mortar is cut off it can be used to butter that end of the last previous brick laid or it can be carried on the trowel back to the box.
16	Tapping Down Brick.	Omit.	If the mortar is the right consistency, with no lumps in it, and the right amount is used, the bricks are wet as possible without having them run, no tapping with the trowel will be necessary.
17	Cutting off Mortar.	Omit.	If the brick must be tapped, hit it once hard enough to hammer it down where it belongs. Do not hit the brick several light taps when one hard tap will do.
18	Disposing of Mortar.	Omit.	Do not cut off the mortar oftener than every second brick, and when you do cut it off do not let fall to the ground; save it; keep it on the trowel, and do not make another motion by throwing it at the box. Carrying it to the box does not count another motion.
18		4↓	Total number of motions per brick.

Chart 1.—Pick and Dip Method, Laying to the Line.

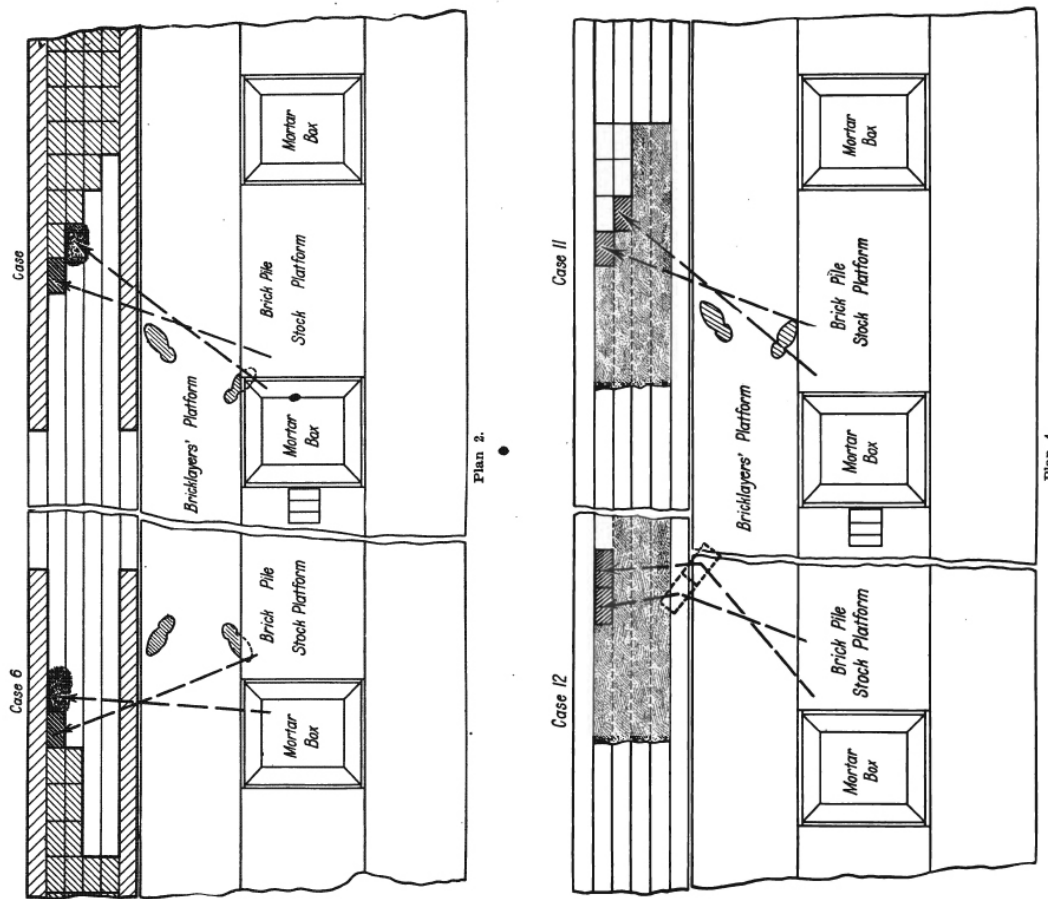


Fig. 20. Plates from F. Gilbreth, *Bricklaying System* (1909) showing Instruction Card study of pick and dip method (top) and motion studies of bricklaying (bottom), also published in *Motion Study* (1911). Source: F. Gilbreth, *Bricklaying System*. New York: Myron C. Clark Publishing, 1909. 148, 153, 154.



Fig. 10.—Massachusetts Institute of Technology, July 20, 1902.

BRICKLAYING SYSTEM.



Fig. 11.—Massachusetts Institute of Technology, July 27, 1902.

METHODS OF CONSTRUCTION.



Fig. 12.—Massachusetts Institute of Technology, Aug. 3, 1902.

BRICKLAYING SYSTEM.



Fig. 13.—Massachusetts Institute of Technology, Aug. 11, 1902.

METHODS OF CONSTRUCTION.



Fig. 14.—Massachusetts Institute of Technology, Aug. 17, 1902.

BRICKLAYING SYSTEM.

Fig. 21. Plates from F. Gilbreth, *Bricklaying System* (1909) showing progress photos of Lowell Lab's, MIT, Boston, MA, construction plant between July 20 and August 17, 1902.

Source: F. Gilbreth, *Bricklaying System*. New York: Myron C. Clark Publishing, 1909. 10-14.

DEPENDABLE SPEED—THE RESULT OF THE GILBRETH SYSTEM AND THE COST-PLUS-A-FIXED-SUM CONTRACT

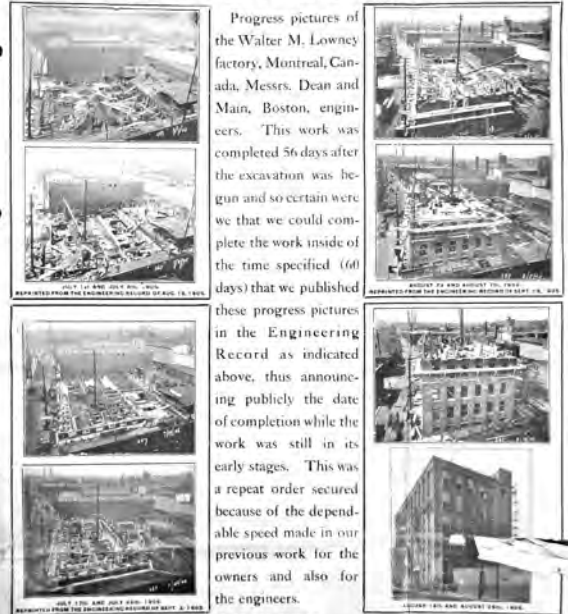
THE ENTIRE TOWN OF SPRACUES FALLS, MAINE



OUR SECOND CONTRACT FOR MR. GEORGE F. HARDY, ENGINEER

FRANK B. GILBRETH, M. AM. SOC. M. E.
 MAIN OFFICE: 34 W. 26TH ST., NEW YORK
 SAN FRANCISCO: 476 PROSPECT AVE., OAKLAND
 SEATTLE: GEORGETOWN, WASH.
 BOSTON: JOHN HANCOCK BLDG.

DEPENDABLE SPEED—THE RESULT OF THE GILBRETH SYSTEM AND THE COST-PLUS-A-FIXED-SUM CONTRACT



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Fig. 22. Pages from special brochure demonstrating F. Gilbreth's progress photo method, part of the Gilbreth System, included as supplement, "Dependable Speed: The Result of the Gilbreth System and the Cost-plus-a-Fixed-Sum Contract" in the May 12, 1906 issue of *Engineer Record*.

Source: FLGA Unsorted Box, Folder 0030-18.

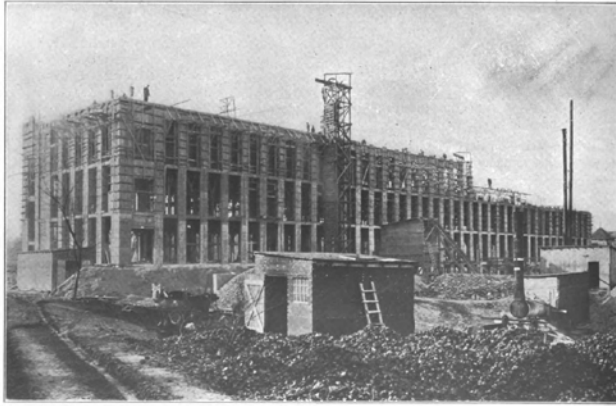


Fig. 63. (Rule 257.)



Fig. 67. (Rule 203.)

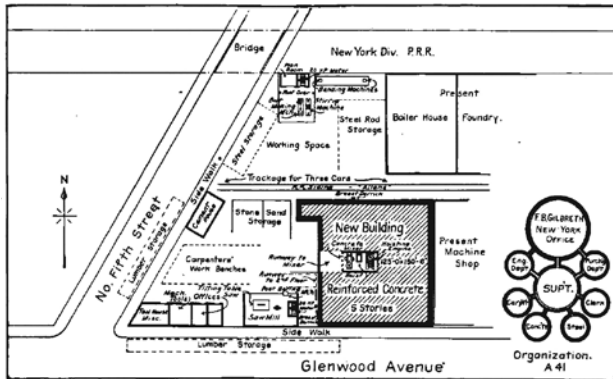


Fig. 5.

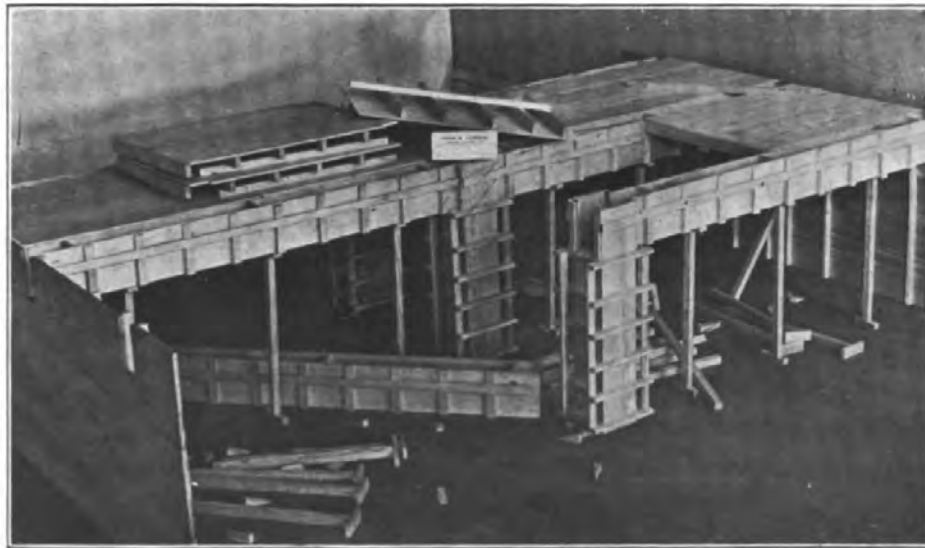
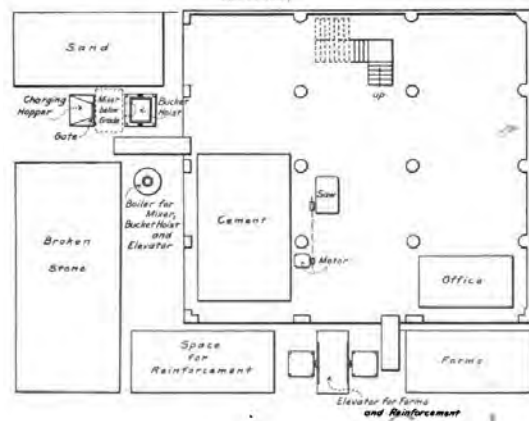


Fig. 9. (Rule 36.)

Fig. 23. Plates from F. Gilbreth, *Concrete System* (1908), showing progress photos (top), construction plant plans at the site and structure scales (middle), and a sketch model of formwork (bottom).
 Source: F. Gilbreth, *Concrete System*. New York: The Engineer News, 1908. 50, 42, 10, 8, 12.

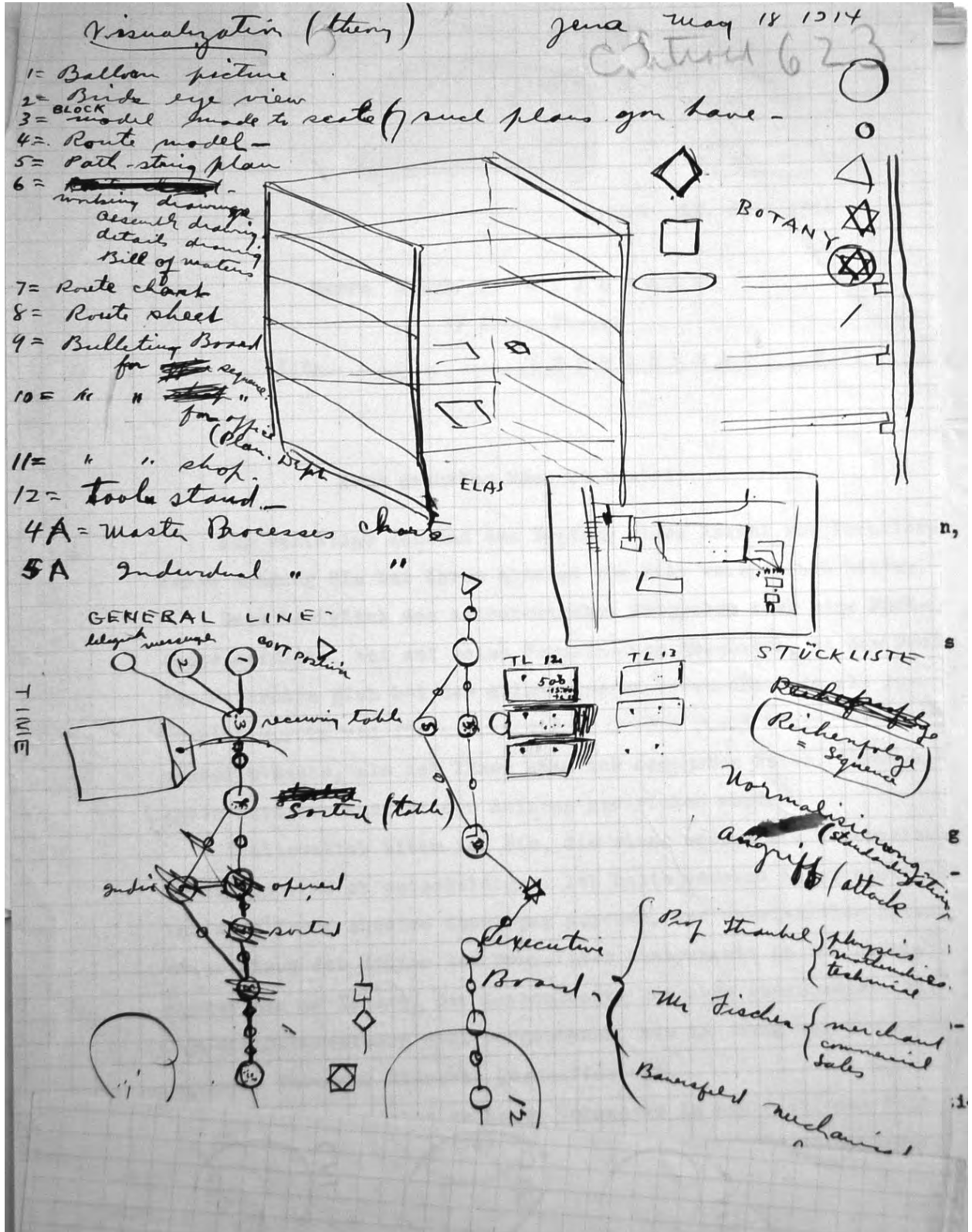


Fig. 24. F. Gilbreth, sketch sheet, labeled "Visualization (Theory)", showing plan for consulting work for Carl Zeiss in Jena, Germany, dated May 18, 1914.

Source: FLGA Box 133 Folder 0957-1 Project 623 "Visualization (Theory)", May 18, 1914.

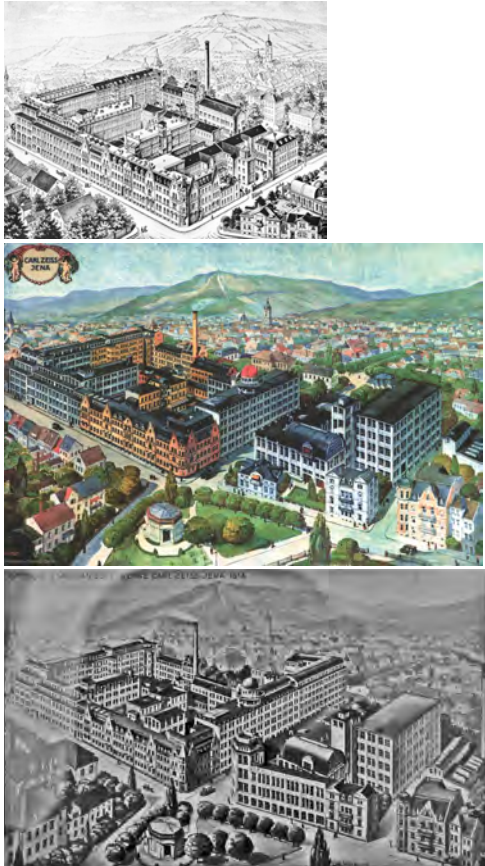


Fig. 25. Birds-eye views of Carl Zeiss plant in Jena, Germany from 1908, 1910 and 1914, showing the rapid change of the facility.

Source: FLGA Box 133 Folder 0957-1 Project 623

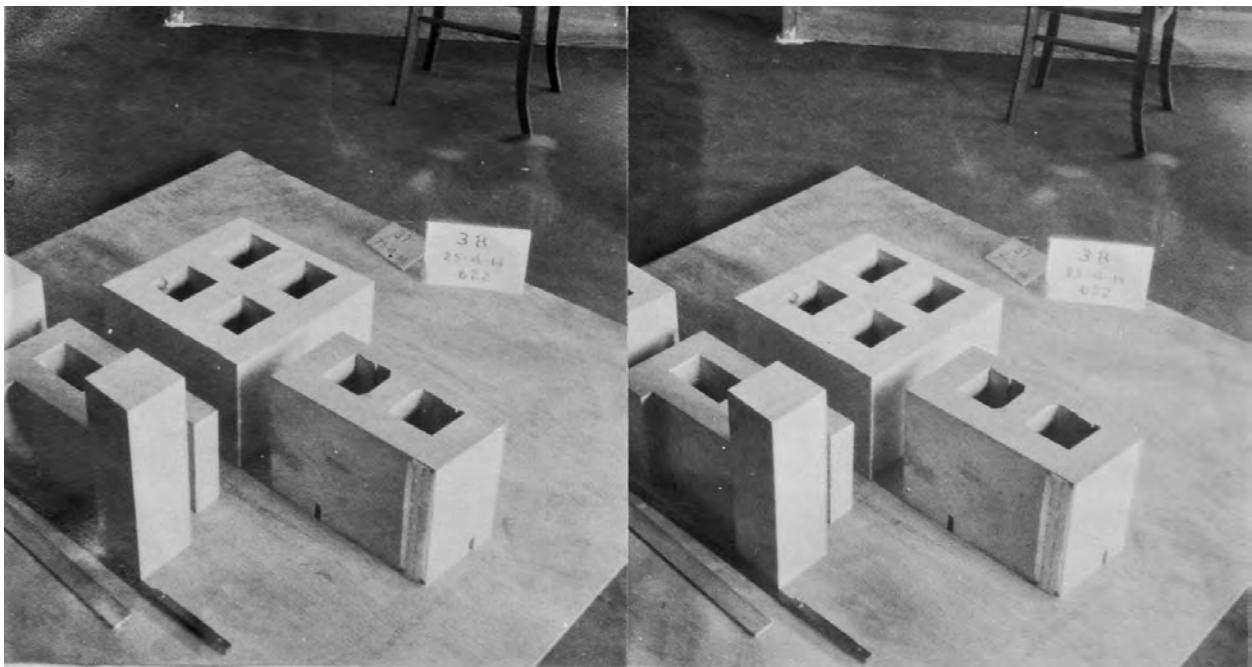


Fig. 26 F. Gilbreth, Stereographic photo of block model of Auer plant, Berlin, Germany, April 25, 1914.

Source: Box 149 Photographs, ca. 1914 and undated. Folder 0031-8 Germany 1914. Project 622

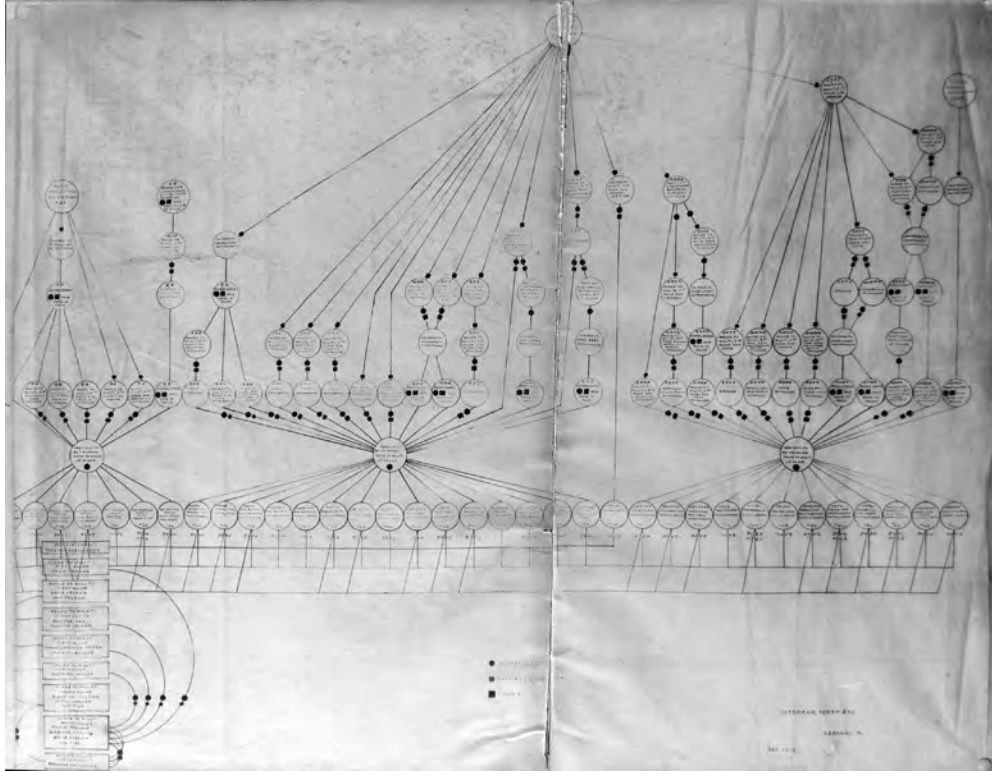


Fig. 28. F. and Lillian Gilbreth, Master Process Chart of Hermann Aukam Co., 1912.
 Source: FLGA Box 85 Industrial Management – Planning, ca. 1912-1925 Folder 0755-3 ‘Hermann Aukam Co. December 1, 1912’

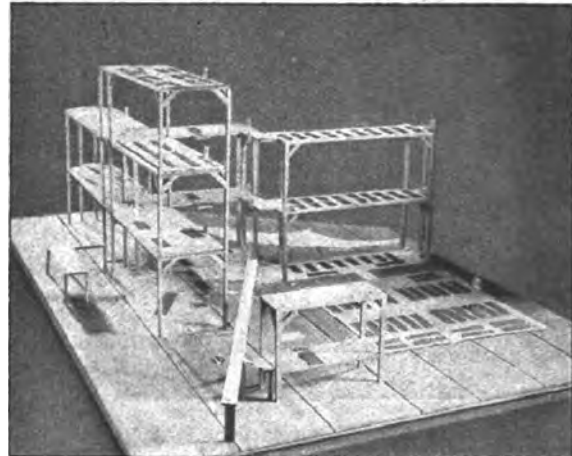


Fig. 9. Systematische Darstellung der Arbeitsverteilung. Die sich analog jedes Arbeitsstückes vorwärtsbewegenden Blättchen orientieren mit einem Blick über die Verteilung der einzelnen Stücke über die Werkstätten.

Fig. 29. F. Gilbreth, progress photo of Herrmann Aukam plant route model, March 22, 1913, with numbers indicating particular points in the production sequence (left) and plate from F. Gilbreth, *Das ABC der wissenschaftlichen Betriebsführung* (1917), showing a photo of the same route model (right).
 Sources: FLGA Box 11 Photographs of Various Studies 1909-1914. Folder 0031-5 - Hermann Aukam Co. – 1913; Gilbreth, Frank B. *Das ABC Der Wissenschaftlichen Betriebsführung*. Translated by Colin Ross. Berlin: Julius Springer, 1921 (1917). 29.



Fig. 30. F. Gilbreth, progress photos of planning room, showing custom work table with numbered positions and in- and outboxes, designed by Gilbreth (left) and numbered storage racks, coordinated with route model and process charts (right), at the Auer plant in Berlin, Germany, 1914.

Source: FLGA Box 149 Photographs, ca. 1914 and undated Folder 0031-8 Germany 1914, Photos 622 169 and 622 03 14.

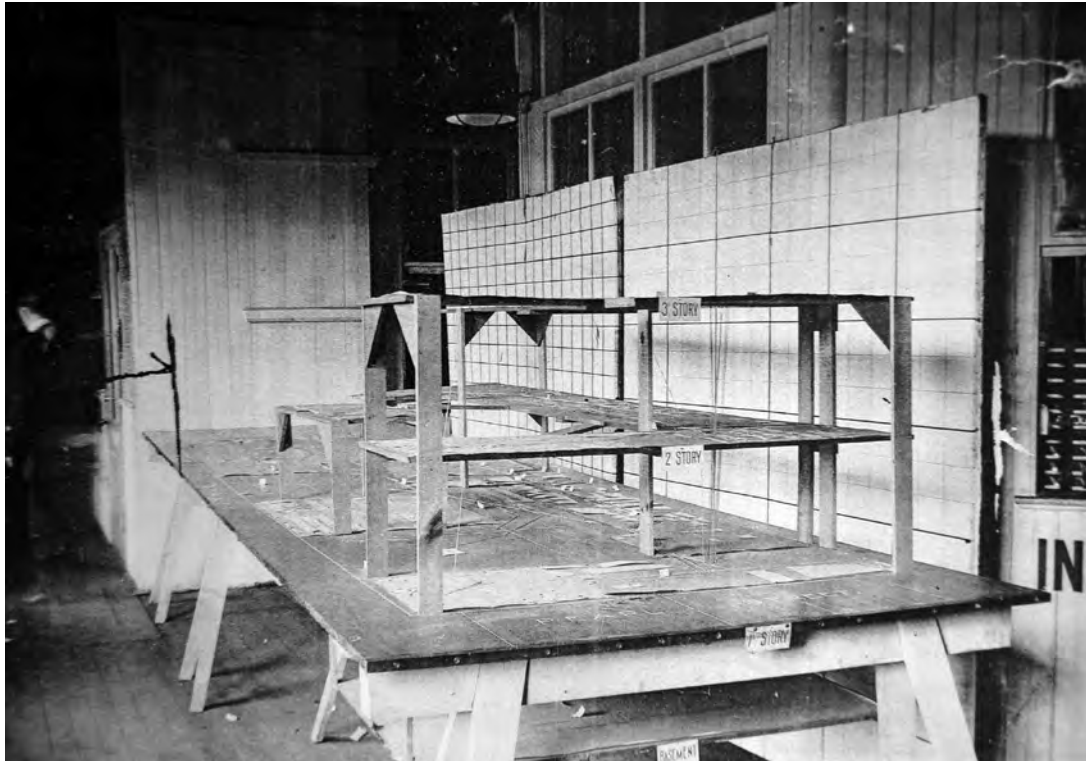


Fig. 31. F. Gilbreth, photograph of NE Butt Plant Route model, 1913, in the same laboratory used for micromotion study of workstations, shown in Fig. 01, same model as shown in Fig. 27.

Source: FLGA Box 11 Photographs of Various Studies 1909-1914. Folder 0031-4 - NE Butt Co- 1913.

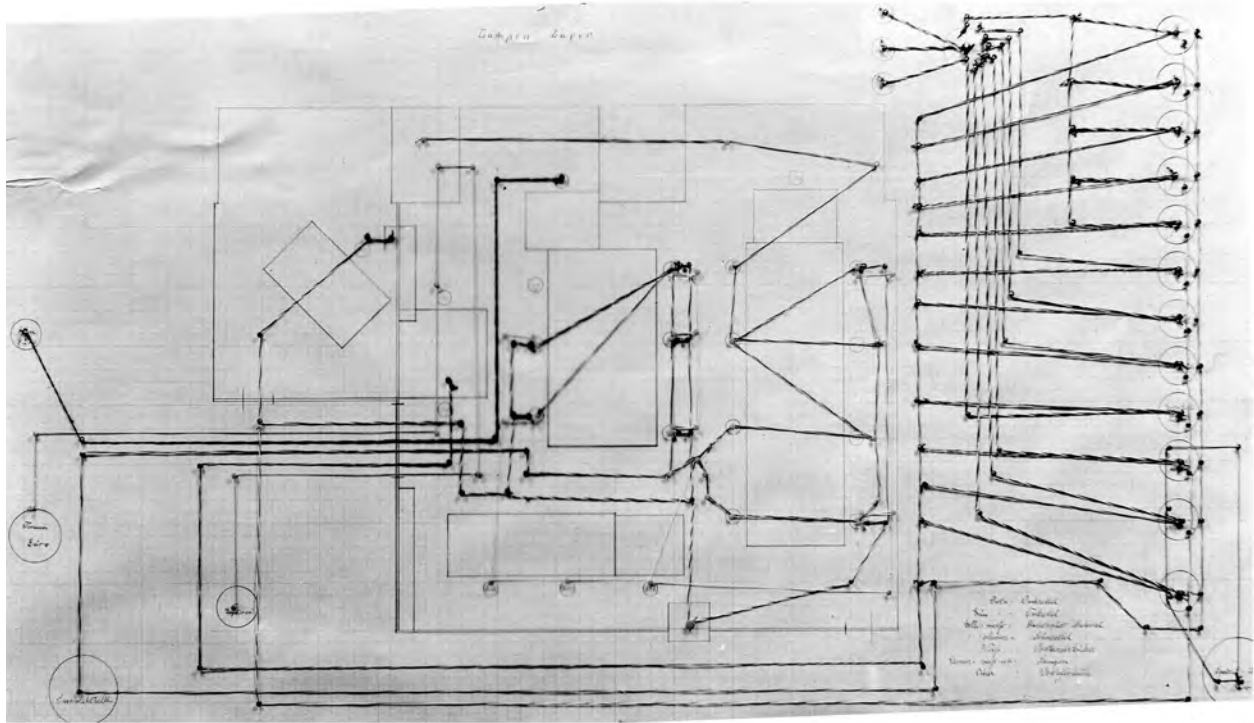


Fig. 32. F. Gilbreth, path string model of route of lamp through part of Auer plant, May 22, 1914.
 Source: FLGA Box Photographs, ca. 1914 and undated Folder 0031-8 Germany 1914 Photo 622 54.

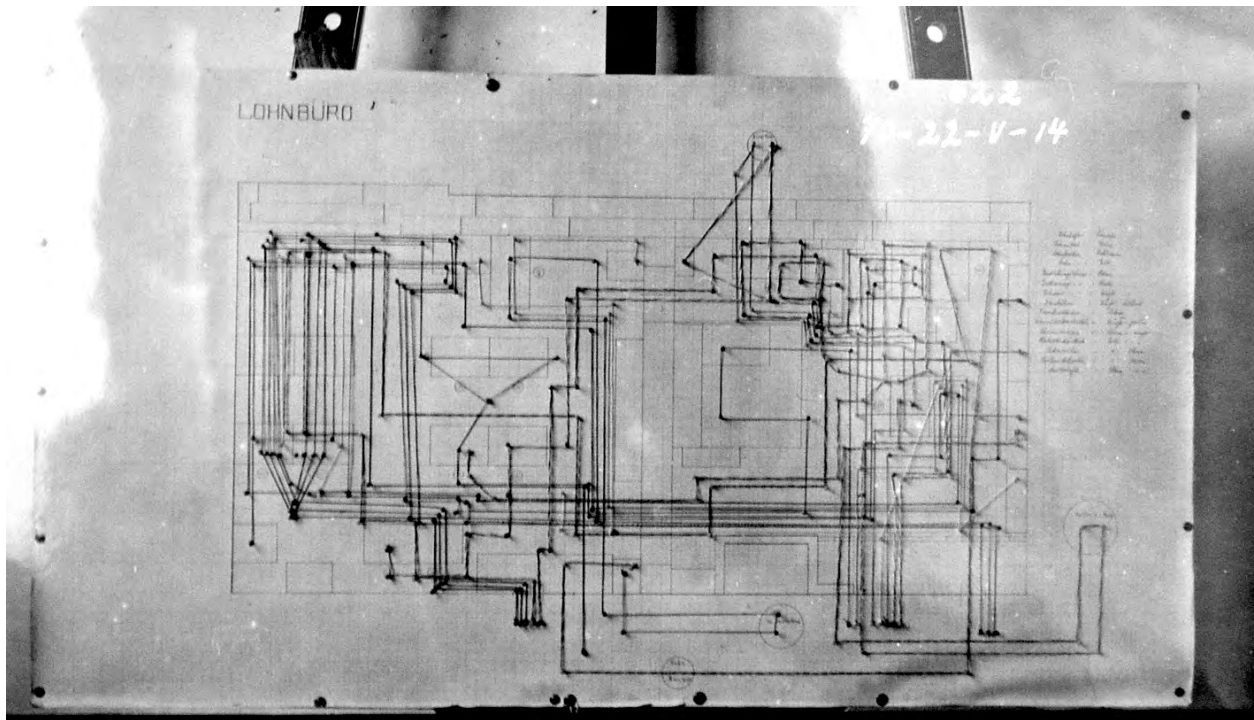


Fig. 33. F. Gilbreth, path string model of routing of paper work through Auer payroll department, May 22, 1914.
 Source: FLGA Box Photographs, ca. 1914 and undated Folder 0031-8 Germany 1914 Photo 622 70.



FIG. 2 STANDARD SYMBOLS FOR PROCESS CHARTS

Fig. 36. Plate from F. and Lillian Gilbreth, "Process Charts" (1922) showing standard symbols for process charts.

Source: Gilbreth, F. and Lillian. "Process Charts and Their Place in Management." *Mechanical Engineering* 44 (1922): 38-41, 70-72.

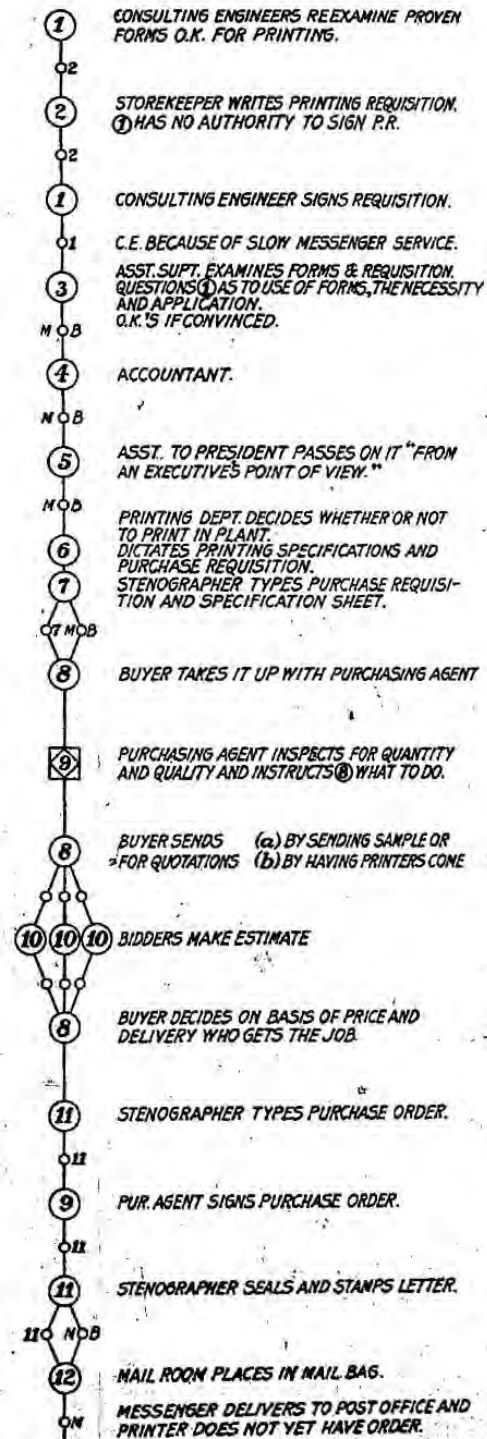
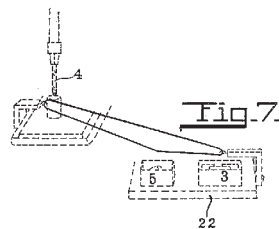
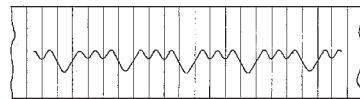
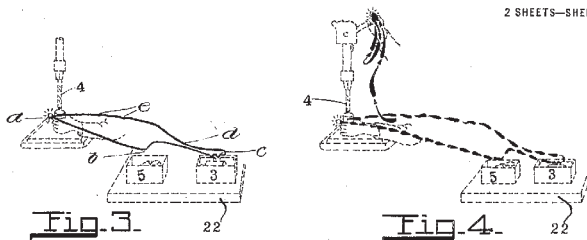
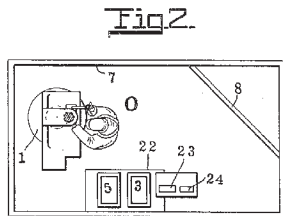
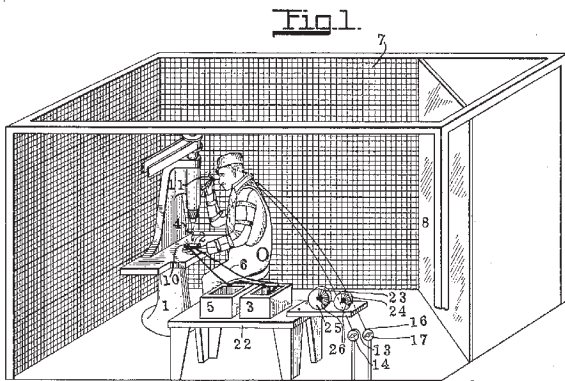
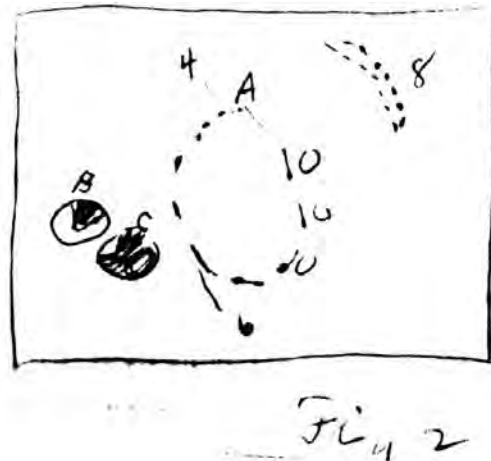


FIG. 7 PROCESS CHART FOR ORDERING BLANK FORMS — PRESENT METHOD

Fig. 37. Plate from F. and Lillian Gilbreth, "Process Charts" (1922) showing process chart for ordering blank forms, prior to experimentation and standardization.

Source: Gilbreth, F. and Lillian. "Process Charts and Their Place in Management." *Mechanical Engineering* 44 (1922): 38-41, 70-72.



2 SHEETS—SHEET 2.

Fig. 39. F. Gilbreth, Sketches of motion study laboratory and cyclegraph (top) and US Patent for Method and Apparatus for the Study and Correction of Motions, filed May 23, 1913, patented Oct. 3, 1916. See Fig. 01 and Fig. 31.

Sources: FLGA Box 45 Motion Cycle, ca. 1913-1940 Folder 0292-1 Cyclegraphs; US Patent 1,199,980

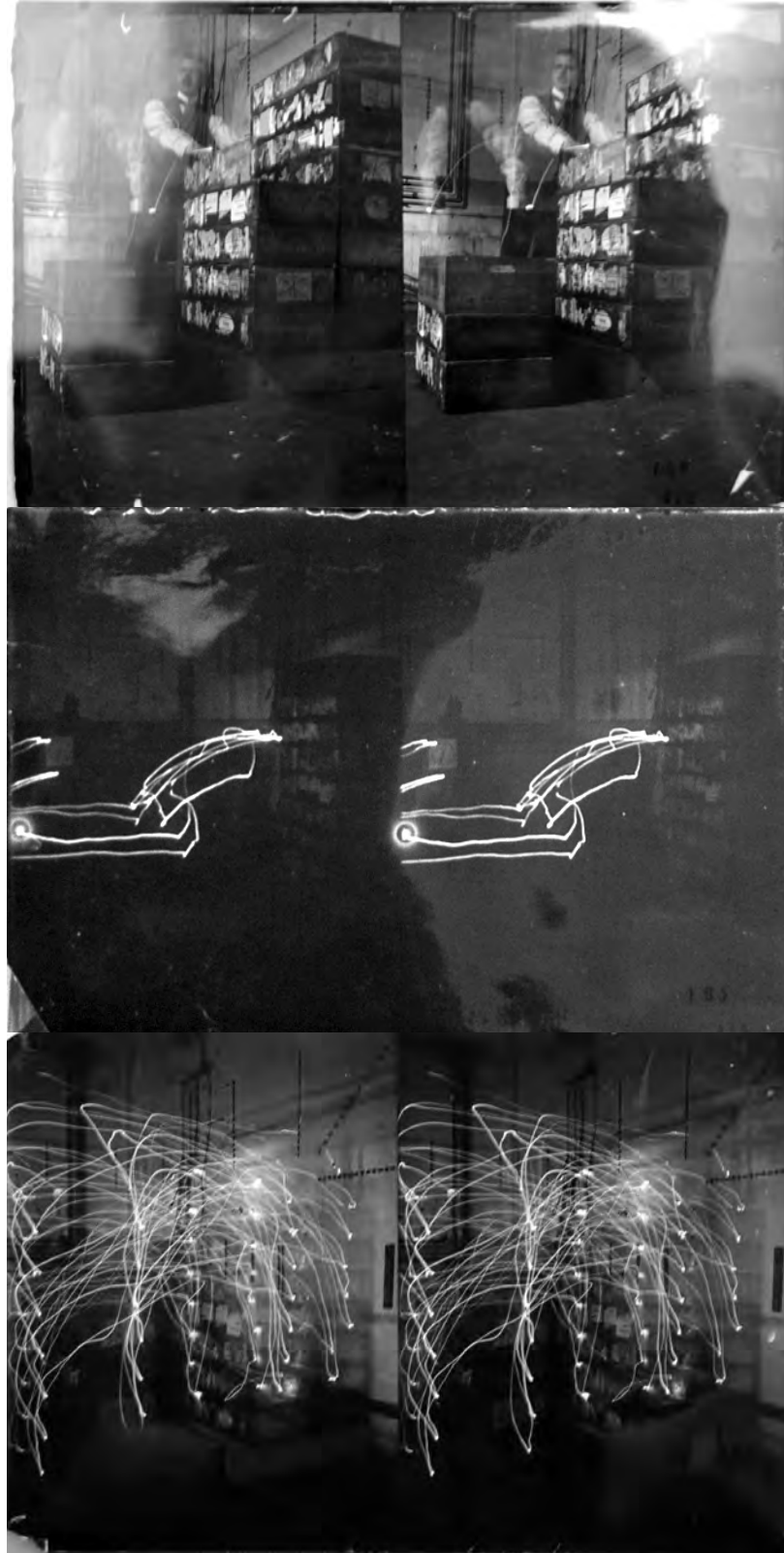


Fig. 40. F. Gilbreth, Series of three stereochronocyclegraphs used to assist in the standardization of a shipping packet for gas lamps at the Auer Plant, Berlin, Germany during the summer of 1914. Source: FLGA Box 146 Photographs, undated Folder 0021 Photos 622-184, 185, 187.

Chapter 3: Figures

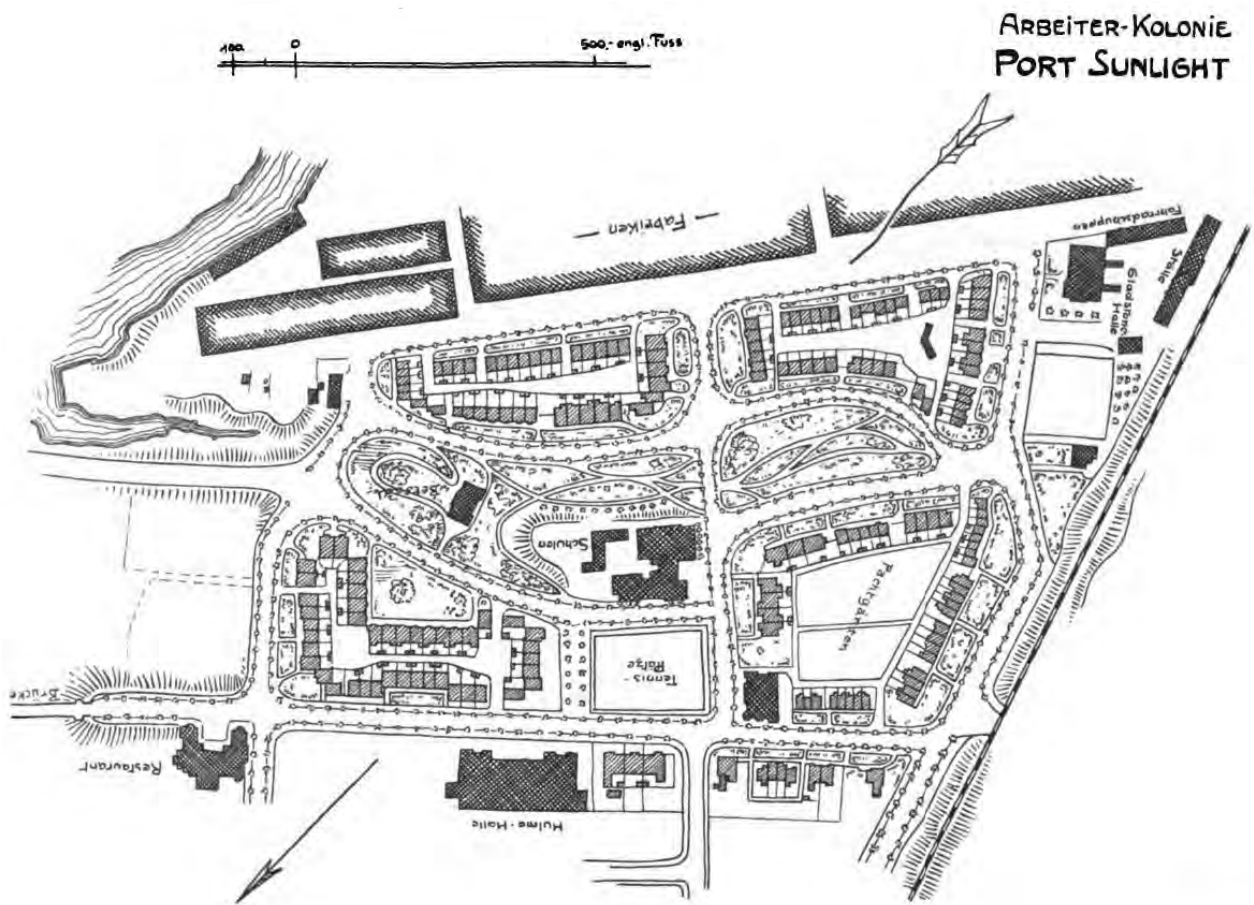
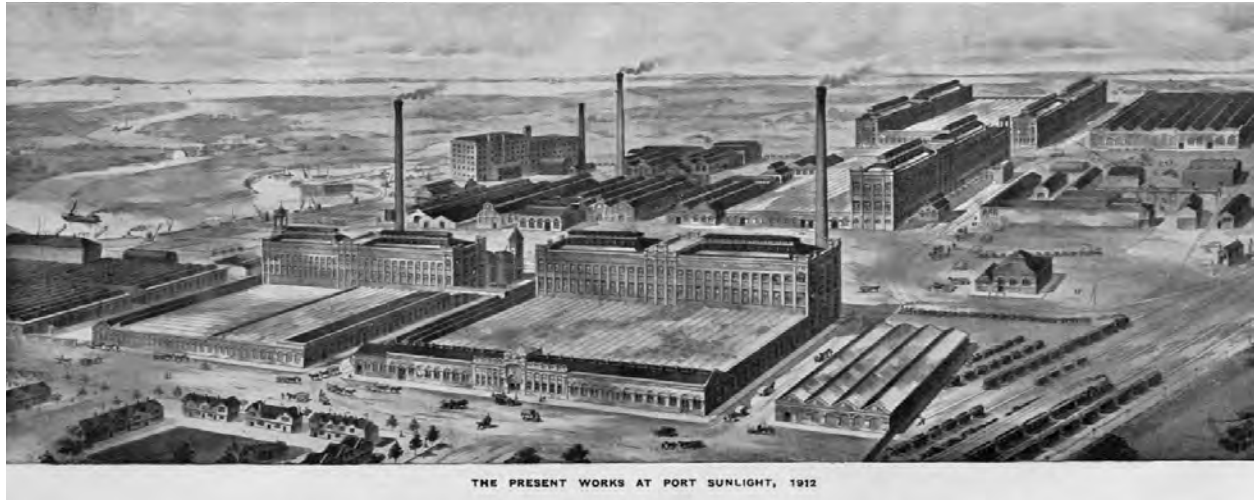


Fig. 41. Plate from *Port Sunlight* (1912) showing the relationship of the industrial plant to the recently constructed 'garden village' in 1910 (top) and plate from *Der Städtebau* (1907), showing the first phase of Port Sunlight, used as an example of grouped or free building arrangement (bottom).
Sources: *Port Sunlight: A Successful Experiment in Prosperity Sharing*: Lever Brothers Limited, 1912; Stubben, J. *Der Städtebau*. Handbuches Der Architektur. 2 ed. Stuttgart: Alfred Kroner, 1907. 348.



Une gare de triage est un organisme indiscutablement fonctionnant. Il n'y a là ni académisme ni arbitraire.

La cité-jardins qui y touche nous inspire une méfiance peut-être motivée : le fonctionnement en est-il vraiment efficace?



Les pêcheurs, leur costume, leur outillage rudimentaire, leurs maisons, la disposition de l'ensemble représentent une sûre organisation. Un événement en totale harmonie : gens, nature et objets : un état de culture.

Harmonie qui doit redevenir nôtre, transposée au plan de la grande ville.

Fig. 42. Plates from Le Corbusier, "Vers La Ville Radieuse - Vivre! (Habiter)" (1931) contrasting the lack of translation of the logics of industrial organization to French garden cities (top) with the organization and harmony of vernacular culture, represented here by a (Breton) fishing village (bottom).

Source: Le Corbusier. "Vers La Ville Radieuse - Vivre! (Habiter)." *Plans 4* (April 1931).

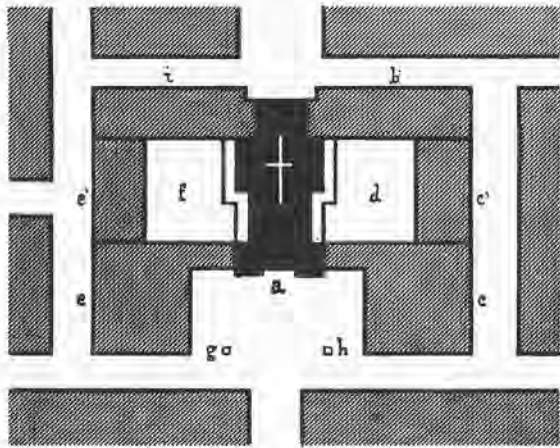
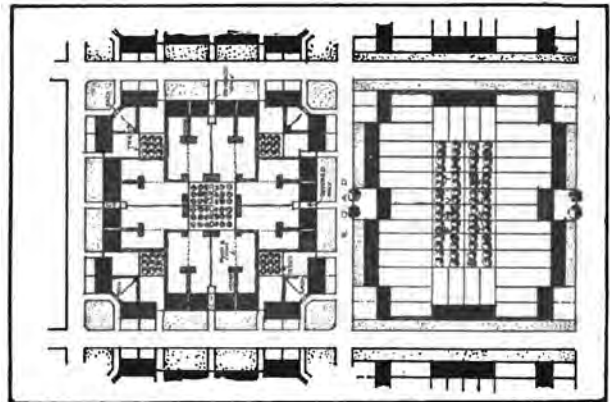


Fig. 103. Camillo Sitte, setting for a church in the Baroque manner



Illus. 281.—Groups of small gardens designed to produce some total effect.

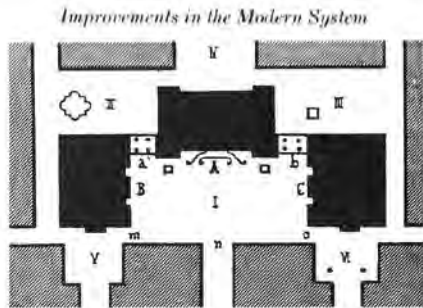
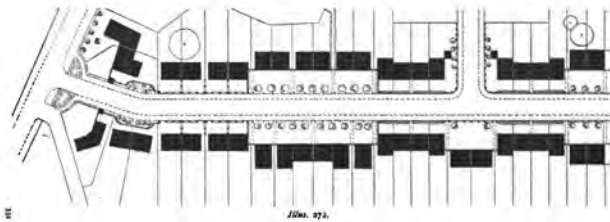


Fig. 105. Camillo Sitte, model layout for a complex of public buildings



Illus. 271.

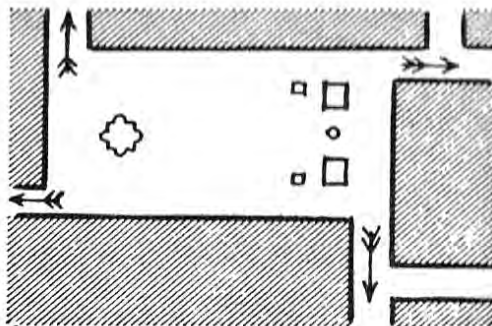
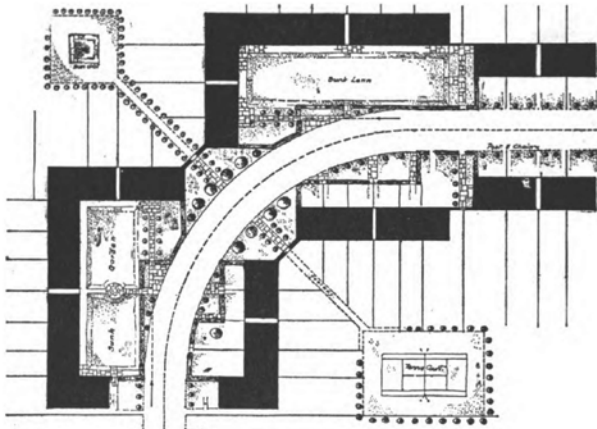
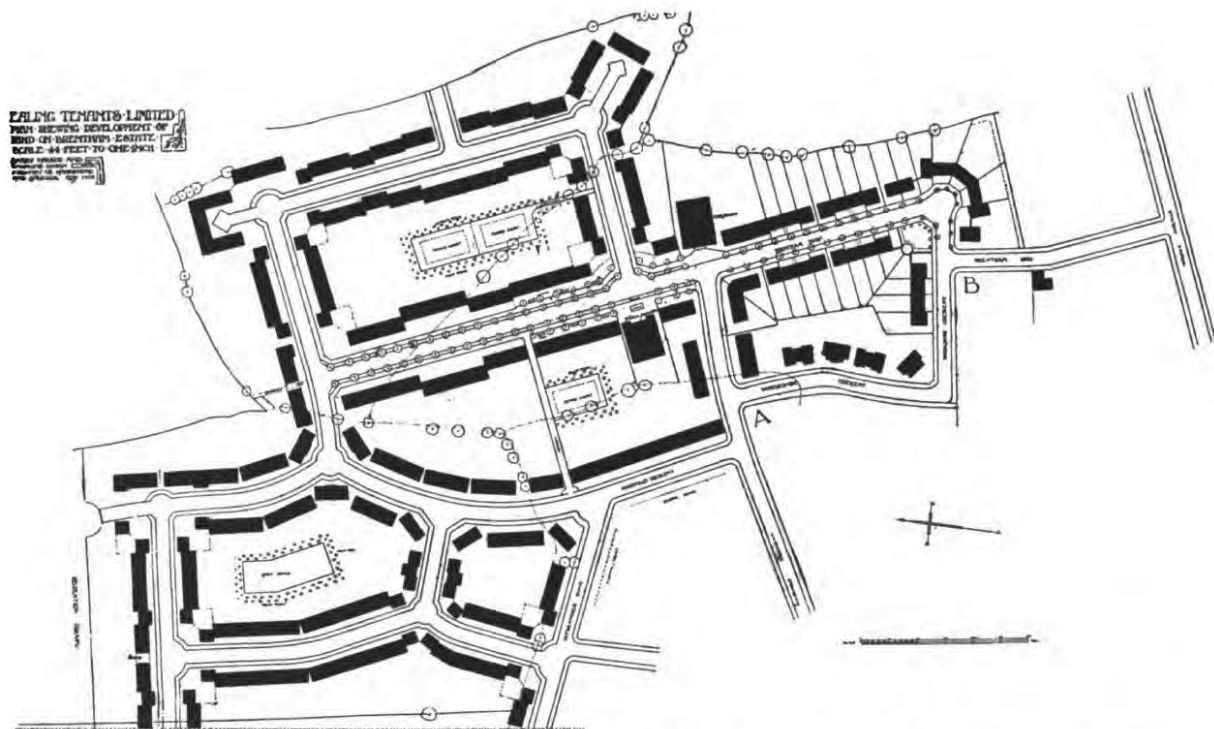


Fig. 108. Camillo Sitte, suggested modern plaza of similar design



Illus. 265.—Groups of buildings designed to maintain square roof lines on a curving road.

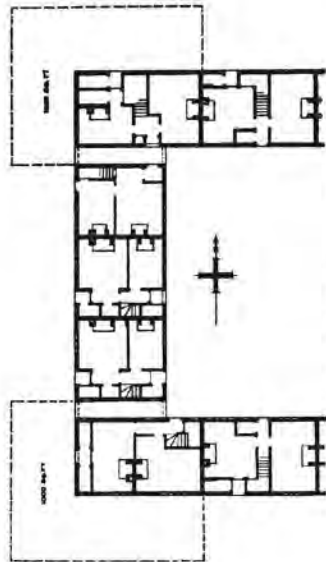
Fig. 43. Plates from Camillo Sitte, "Improvements to the Modern System" (1889) showing artistic city-building principles applied to a modern system of urban parcels and blocks (left) and plates from Raymond Unwin, *Town Planning in Practice* (1909), showing formal and informal groups of buildings that form places, streets and courts (right). All three of the Sitte plates also appear in Unwin's manual. Sources: Sitte, Camillo. "Improvements in the Modern System." Translated by Charles T. Stewart. In *The Art of Building Cities: City Building According to Its Artistic Fundamentals*. London: Martin Fine Books, 2013 (1889); Unwin, Raymond. *Town Planning in Practice: An Introduction to the Art of Designing Cities and Suburbs*. London: T Fisher Unwin, 1909.



*Illus. 169.—Plan of the Ealing Tenants' Estate.
The making of Brentham Way, leading from the Estate to Mount Avenue, was not permitted, because its length exceeded 600 feet, until land was acquired enabling the cross-road A, B to be planned.*

Fig. 44. Plate from *Town Planning in Practice* showing settlement plan of Parker and Unwin's Ealing Tenants Estate. Compare to Figs. 70, 81, 136 and 208.

Source: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 231.



Illus. 297a.—Diagram showing completion of internal sewage.

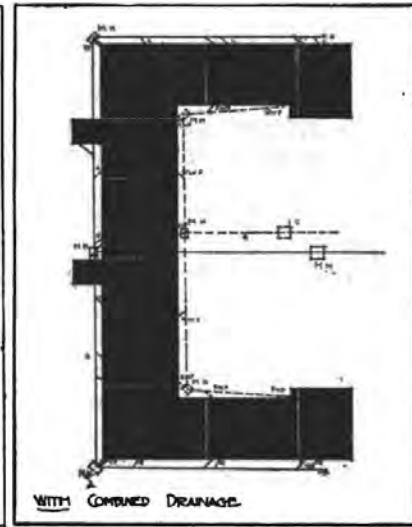
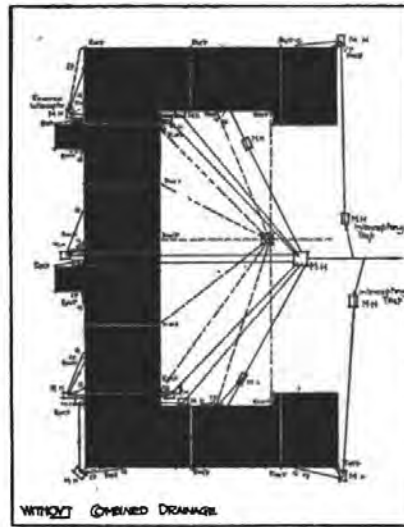
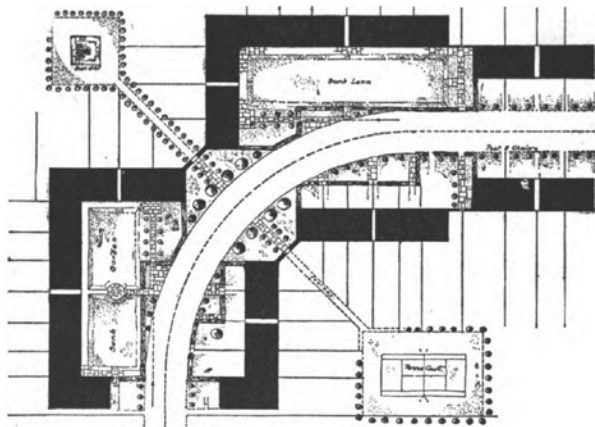


Diagram 3. Diagram 4.
Illus. 298.—Diagrams showing the simplicity of combined drainage for groups of cottages as compared with separate drainage.



Illus. 265.—Groups of buildings designed to maintain square roof lines on a curving road.

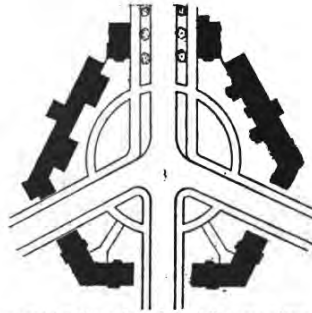


Illus. 266.—Imaginary sketch of village scene where the buildings are square with each other on a road curving as shown on Illus. 265.

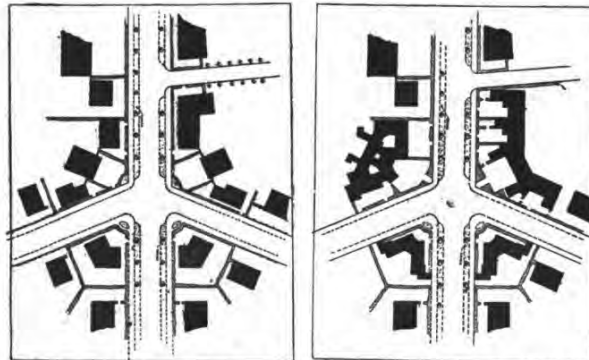
Fig. 45. Plates from *Town Planning in Practice* showing the scale and intricacy of Unwin's design methodology, combining the settlement and unit scales and simultaneously considering site design, typological organization and visual planning. Compare "group of buildings designed to maintain square roof line" with Fig. 95. Source: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 399, 401, 346, 347.



Illus. 85.—View of the Amalienberg Flats, Copenhagen, taken from the direction indicated by the arrow on Illus. 84.



Illus. 261.—Irregular road junction where the buildings are planned to finish squares with each road in groups, forming an hexagonal figure.



Illus. 26a.—Irregular road junction planned for detached buildings affording terminals to two of the road pictures, and frames for the remainder.

Illus. 26aa.—Plan of buildings for the same junction as Illus. 26a, designed in groups by Mr. M. H. Baillie Scott.

Handwritten Garden-Suburb - Proposed Rahmen-Strassenbau der Stadt von 1904 224 225 226 6 227

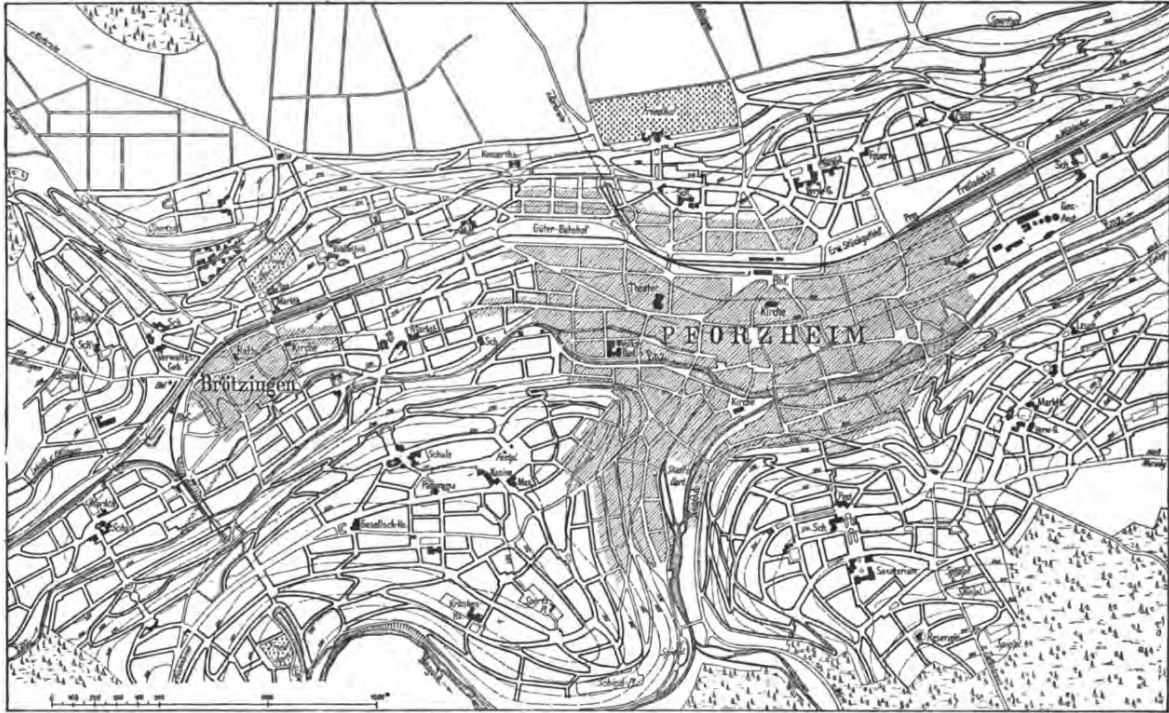


View from corner of Meadway and Hampstead Way

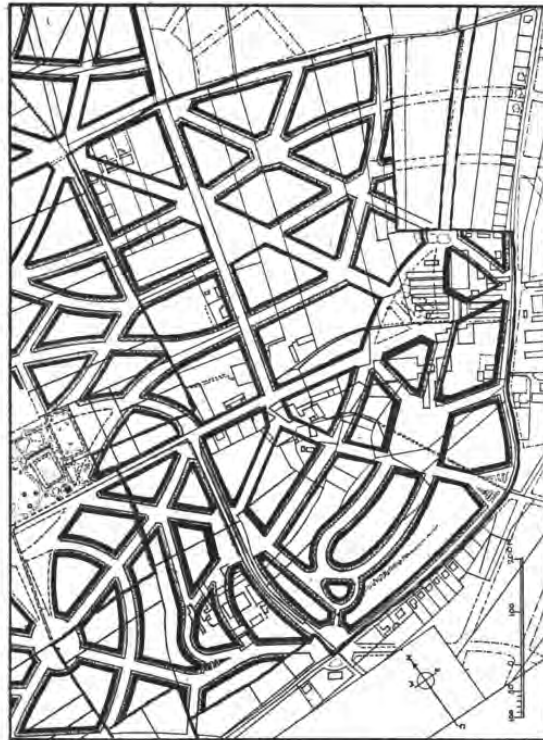
2011 Pointe de la - Nord - France - 1904 - 1905 - 1906

Abb. 23. Garden Suburb Hampstead. Straßenecke Meadway und Hampstead Way, Architekt: M. H. Baillie Scott

Fig. 46. Plates from *Town Planning in Practice* showing Unwin's use of general precedents (top), organizational schemes developed through work at Hampstead (middle) and plate from Berlepsch-Valendas, "Hampstead", showing M. H. Baillie Scott's architectural elaboration of Unwin's organization diagram (bottom). Sources: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 117, 343; Berlepsch-Valendas, Hans Eduard von. "Hampstead— Eine Studie Über Städtebau in England [Hampstead – a Study of High City Building in England]." *Kunst und Kunsthandwerk* 12 (1909): 241-84.



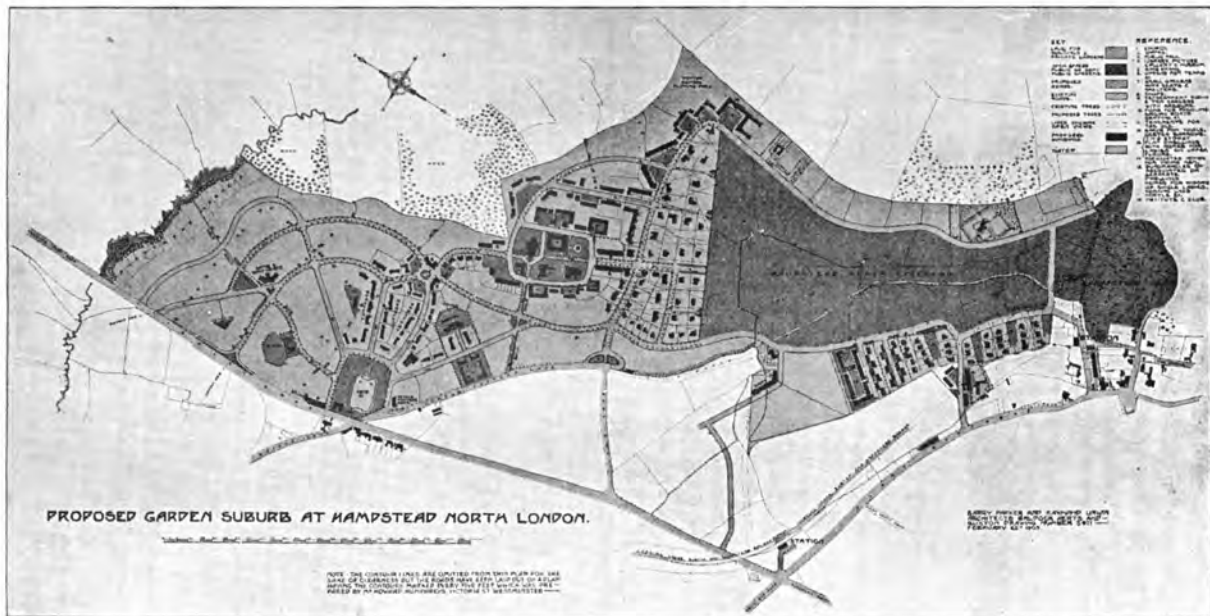
*Illus. 71.—Prize Plan of Pforzheim by Herr Thomas Langenberger.
By kind permission of the Editor of "Der Städtebau."*



*Illus. 78.—Municipal Building Plan for Zschertnitz, near Dresden.
By kind permission of the Editor of "Der Städtebau."*

Fig. 47. Plates from *Town Planning in Practice* showing two examples of the German Irregular School of town planning, Thomas Langerbergers' Plan for Pforzheim (top) and a Municipal Building Plan for a part of Dresden (bottom).

Source: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 100, 108.



THE ESTATE OF THE HAMPSTEAD SUBURB TRUST. See Appendix B.

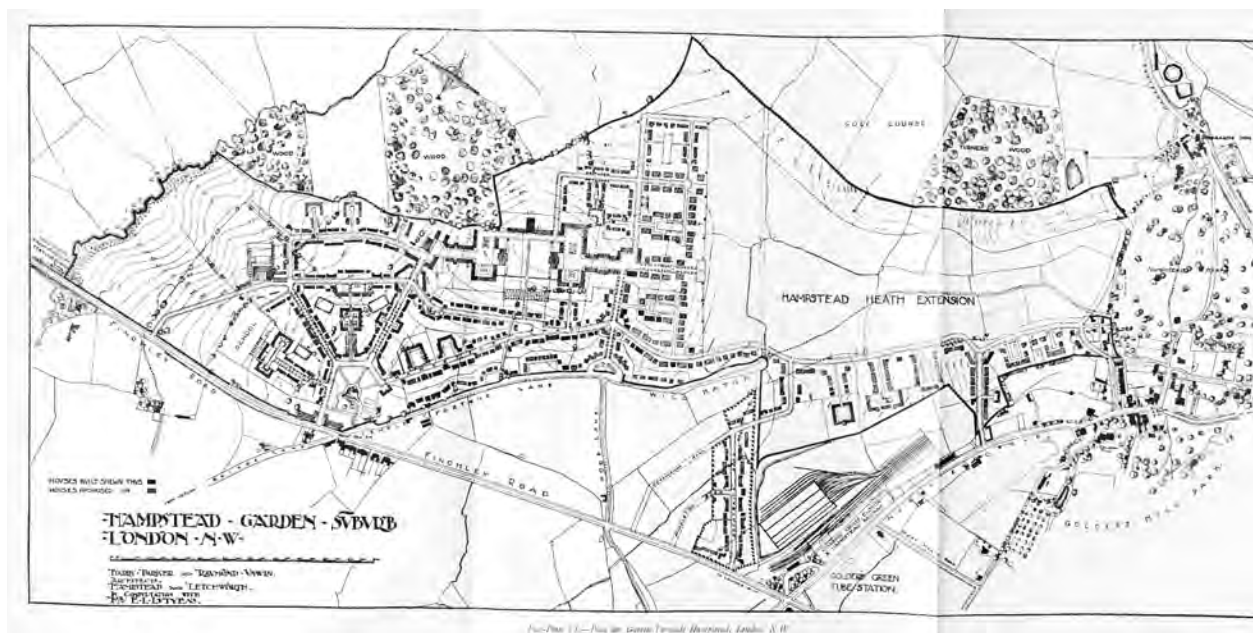
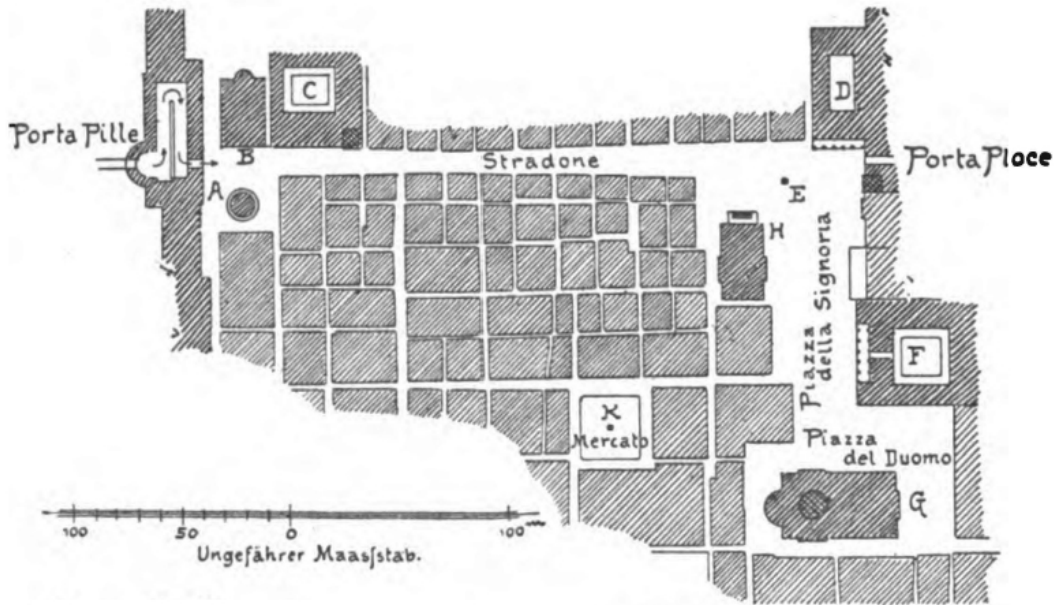
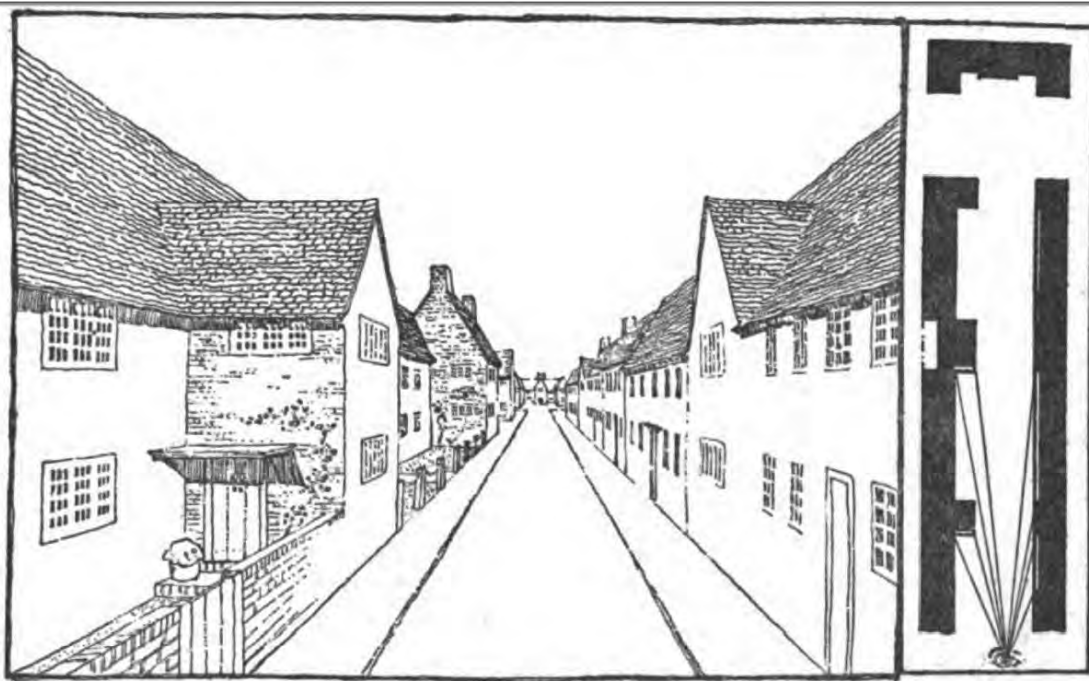


Fig. 48. Unwin and Parkers initial scheme for Hampstead Garden Suburb (February 1907) showing the more “wiggly” approach of the English landscape school of town planning (top), and final scheme for the first phase of Hampstead (1909), showing a marked separation of the simpler geometry of traffic corridors and the more active role of architectural groupings in the formation of the spaces of the settlement (bottom).

Sources: *Town Planning in Theory and Practice*. Town-Planning Conference Proceedings. London: The Garden City Association, October 25, 1907; Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909.



*Illus. 39.—Ragusa in Dalmatia.
Reproduced by kind permission of
Dr. Stübgen.*



Illus. 191.—Plan and sketch of street showing on one side the uninteresting vanishing perspective of the unbroken building line, and on the other the more picturesque result of breaks.

Fig. 49. Plates from *Town Planning in Practice* showing the active role of diverse architectural units in shaping the space of the settlement, through a historical example, Ragusa (Dubrovnik, Croatia) (top) and through an abstract organization scheme (bottom). Compare to Figs. 90, 91, 92, 141, 146 and 207.

Source: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 60, 259.

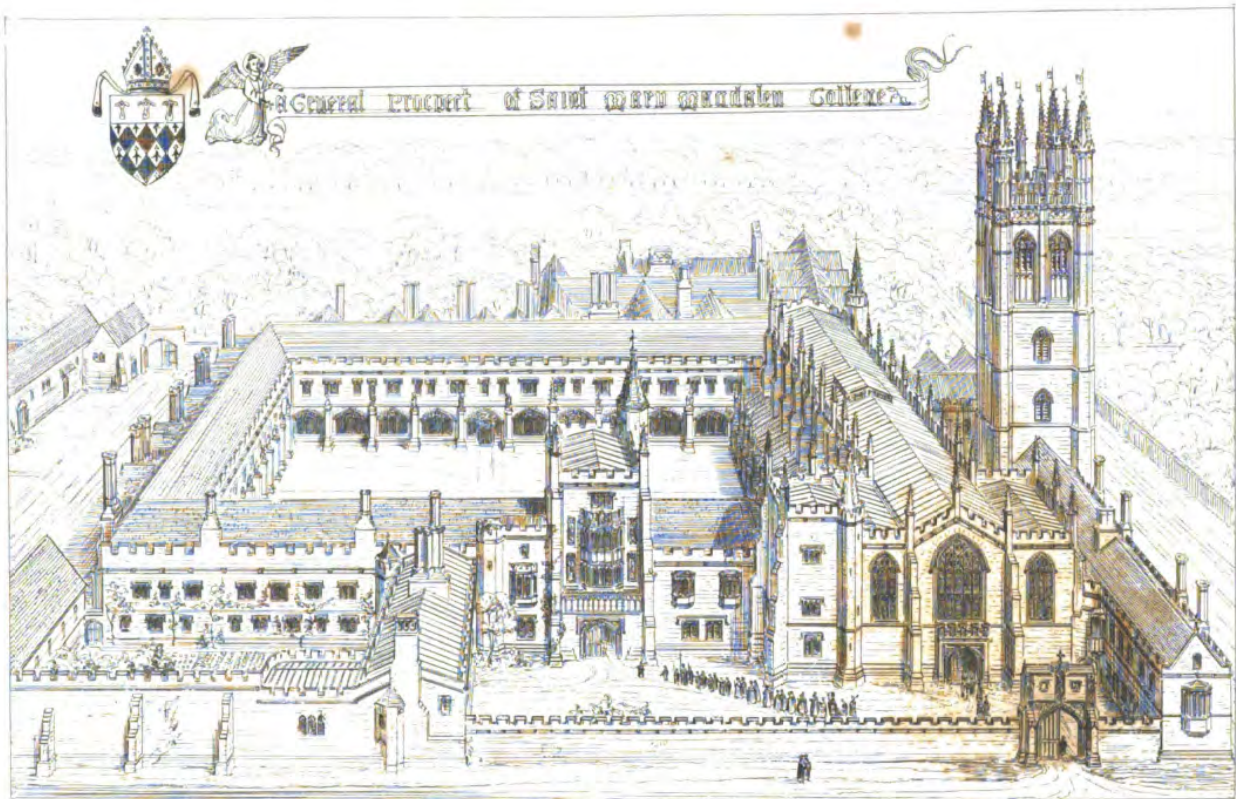


Plate IX

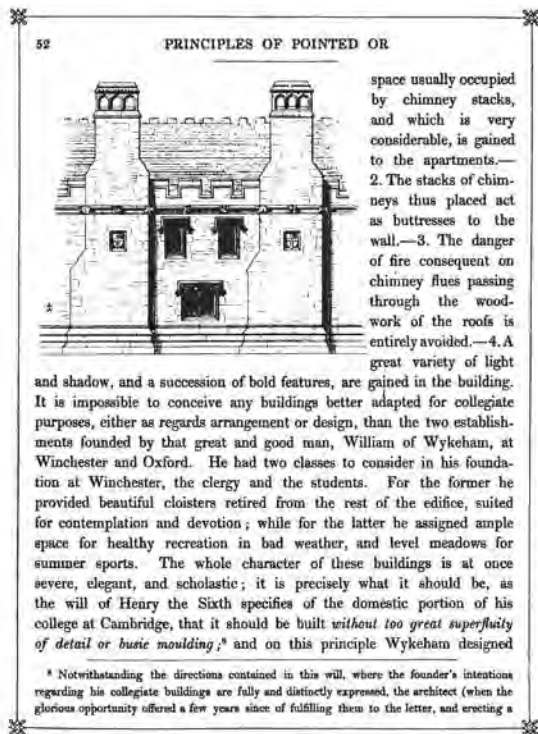
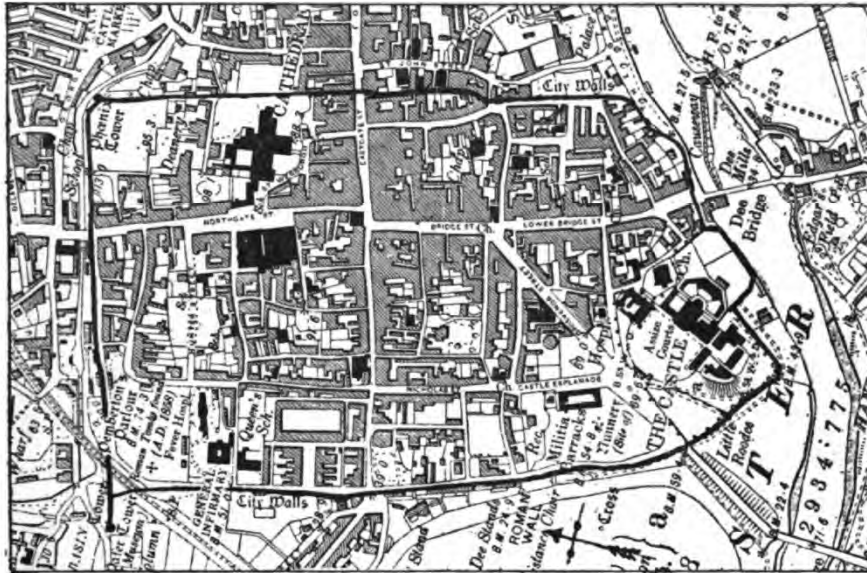
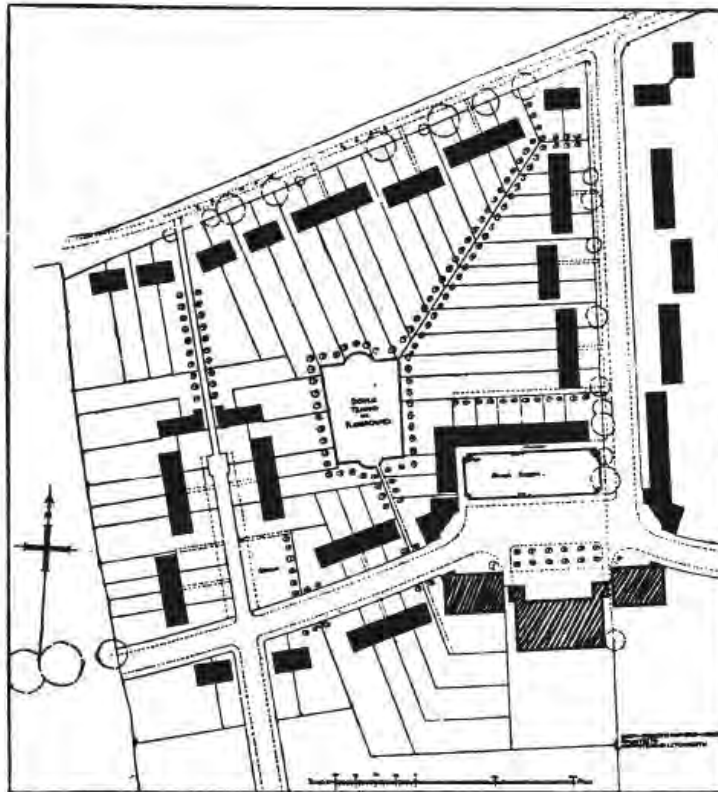


Fig. 50. Plates from Pugin, *The True Principles of Pointed Christian Architecture*, showing Saint Mary Magdalen College, Oxford University, at the ensemble (top) and unit scales (bottom).

Source: Pugin, Augustus Welby. *The True Principles of Pointed Christian Architecture*. London, 1841. 51-52.



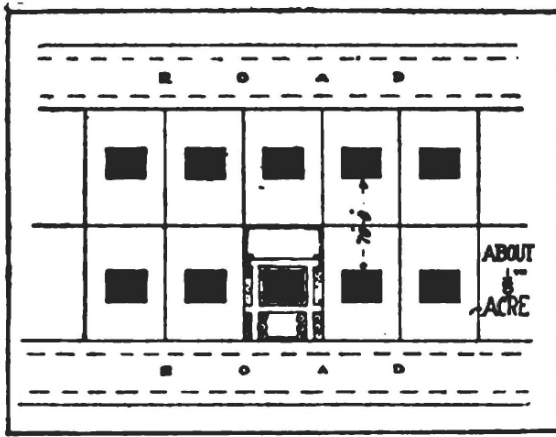
Illus. 4.—Plan of Chester, showing development based on lines of early Roman Camp. Reproduced from the Ordnance Survey Map, with the sanction of the Controller of H.M.'s Stationery Office.



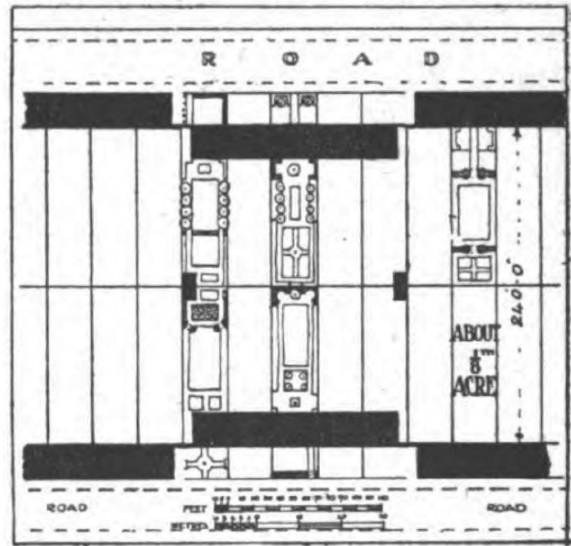
Illus. 170.—Leicester Anchor Tenants' Estate. Plan showing part of the estate with the village centre.

Fig. 51. Plates from *Town Planning in Practice* showing two examples of a simple regular frame and more elaborate irregular architectural groupings, the plan of Chester, with medieval fabric overlaid on a Roman camp organization (top) and Parker and Unwin's Leicester Tenants Estate (bottom).

Source: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 4, 252.



Illus. 269.—Detached houses in centre of blots. Eight houses to the acre.



Illus. 270.—Plan showing extra depth of garden and distance apart of the houses when they are built in groups, also eight to the acre.

Fig. 52. Plates from *Town Planning in Practice* contrasting typical suburban development (right) with houses in groups (left). Compare with Figs. 55 and 77.

Source: Unwin. *Town Planning in Practice*. London: T Fisher Unwin, 1909. 350.



ON THE WAY TOWARD STANDARDIZATION: A SECTOR OF BROOKLYN
 The jerry-builder replacing the architect. Not only are stereotypes frequently repeated, but every house is largely an assembly of standard parts from the factory. Bathrooms have come; gardens have gone. Every house is but the visible shoot upon a great underground root mechanism, constituting "the land and its improvement..."



THE ARCHITECT'S ATTEMPT TO INDIVIDUALIZE AN INDUSTRIAL VILLAGE: FOREST HILLS
 An attempt that failed. The cost of spaciousness and individual design was too high for workers and the houses are now occupied by the middle classes. To the rear is seen the invasion of the jerry-building that must serve the poorer man who wishes to live in a "free-standing" house.

Fig. 53 Plates from Mumford, "Mass-Production and the Modern House" comparing typical housing construction in Brooklyn (left) and Forest Hills Gardens, Queens (right).

Source: Mumford, Lewis. "Mass-Production and the Modern House." *The Architectural Record* (1930): 13-20.

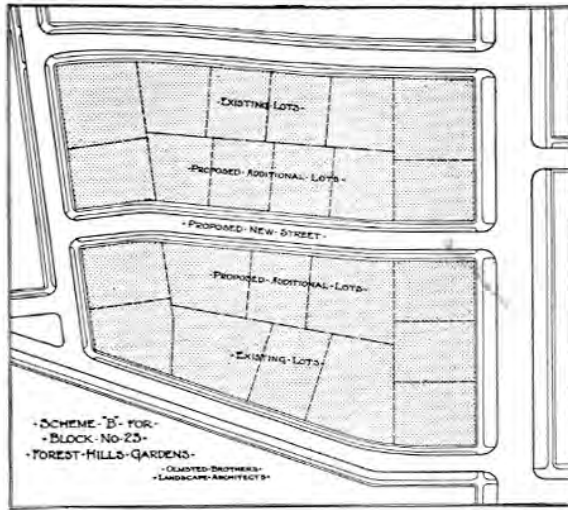


Diagram No. 6.

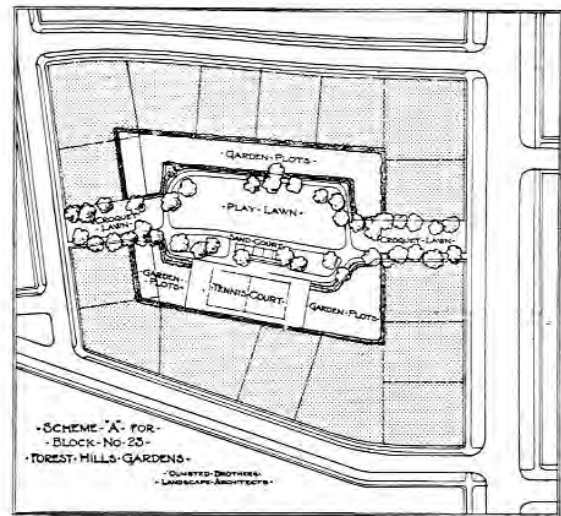


Diagram No. 5.

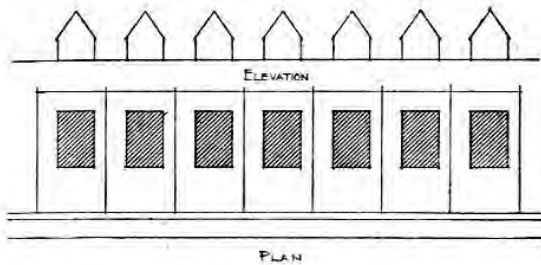


Diagram No. 1.

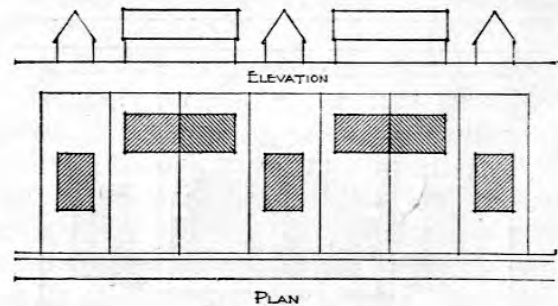
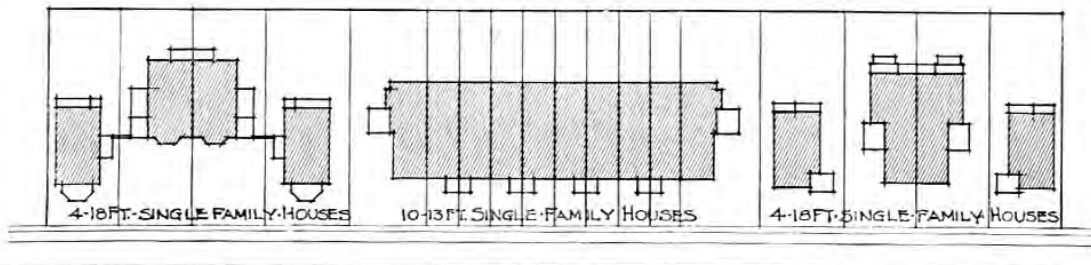


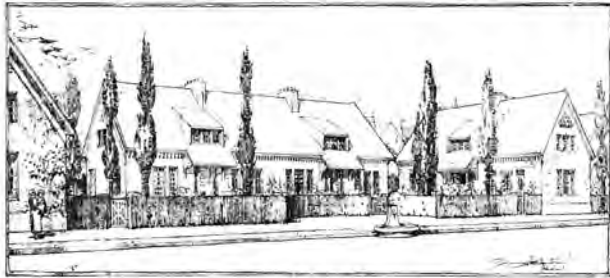
Diagram No. 2.



Forest Hills Gardens.
and block houses disposed with a view to land economy and avoidance of monotony.

Fig. 54. Plates from Grosvenor Atterbury, "Model Towns in America" showing the architect's grouping of houses (top) and formation of a place within a court scheme (bottom), following Unwin's principles of town planning.

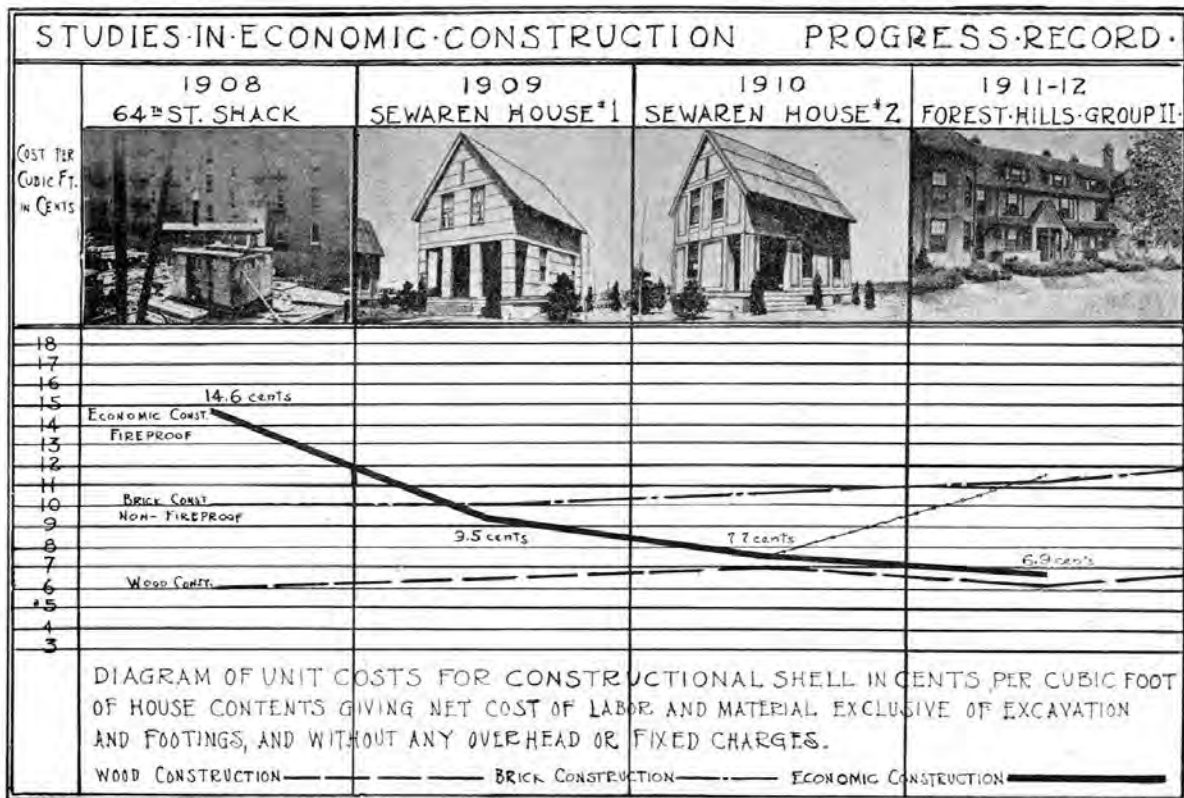
Source: Atterbury, Grosvenor. "Model Towns in America." *Scribner's* 52 (July 1912): 20-35.



Group for Single and Semi-Detached Dwellings.



Houses at Seawarren, N. J. Erected 1908-9. Standardized Hollow Concrete Construction Throughout.



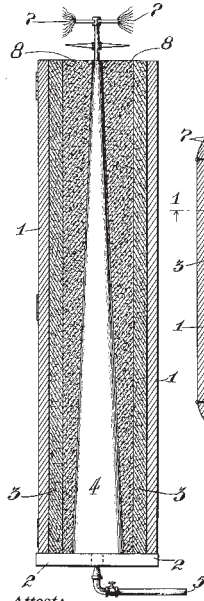
Note.—In the case of Forest Hills Group II, the cost of 6.9 cents per cubic foot of house contents applies to that part of the construction which was standardized. The cost of the group as a whole (11.25 cents) is indicated by the line diverging from the heavy black line.

Fig. 55. Plates from Atterbury, *The Manufacture of Standardized Houses* showing a perspectival study of a group of single and semi-detached houses (top left), a photograph of the Sewaren Houses (top right) and a progress record of Atterbury's experimental units, from 1908-1912 (bottom). Source: Atterbury, Grosvenor. *The Manufacture of Standardized Houses: A New Industry*. New York: Standardized Housing Corporation, 1918.

1,171,579.

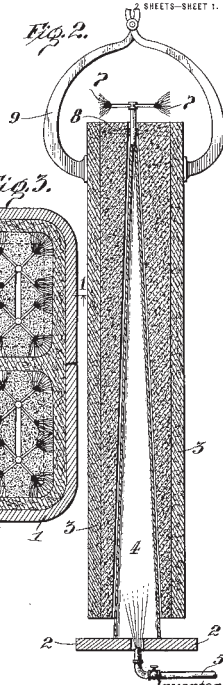
Patented Feb. 15, 1916.
SHEETS—SHEET 1.

Fig. 1.



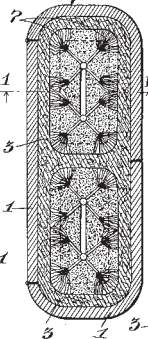
Attest:
G. S. Ashley
T. S. Alstead

Fig. 2.

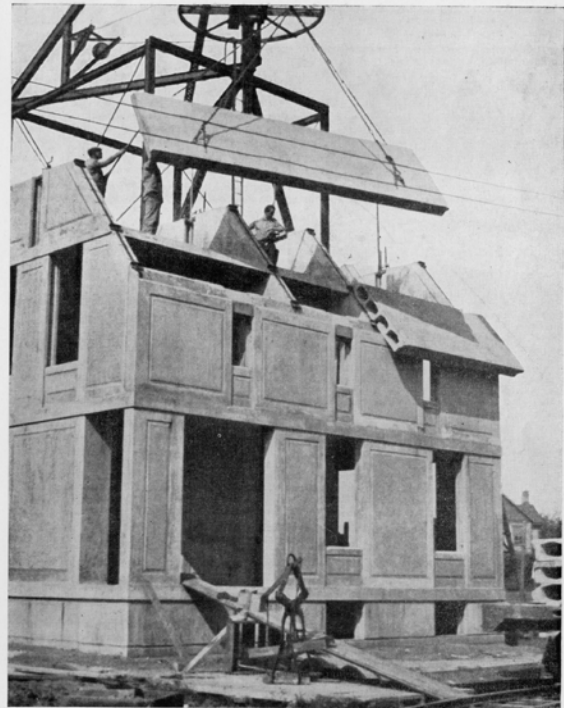


Inventor:
Grosvenor Atterbury
by *Reed, Hafford, Smith, Allen*
Attys

Fig. 3.



Setting Wall Block, Third Tier. Crew Consists of Hoisting Engineer, Foreman and Two Laborers. House Erected in Fifteen Working Days.



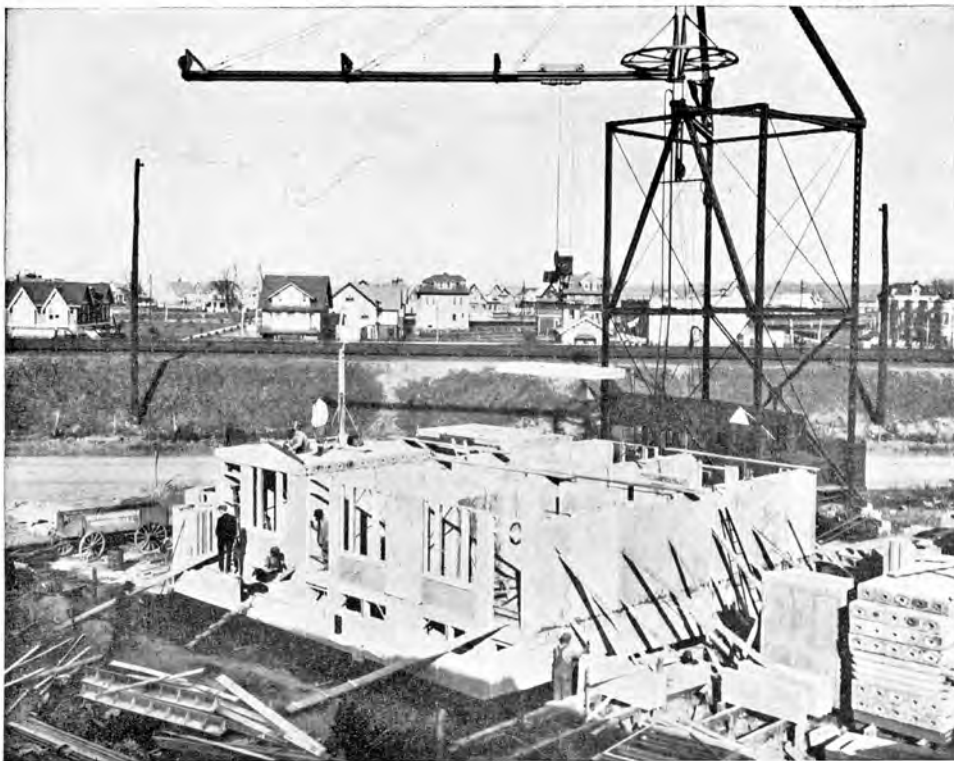
Setting Roof Block.

Fig. 56. Drawings of Atterbury's "apparatus for molding or casting" reinforced concrete panels, part of his patent application, filed in 1909 and patented in 1916 (top) and plates from Atterbury, *The Manufacture of Standardized Houses* showing the assembly of Sewaren House #2 (1909) (bottom).

Sources: US Patent 1,171,579; Atterbury. *The Manufacture of Standardized Houses: A New Industry*. New York: Standardized Housing Corporation, 1918.



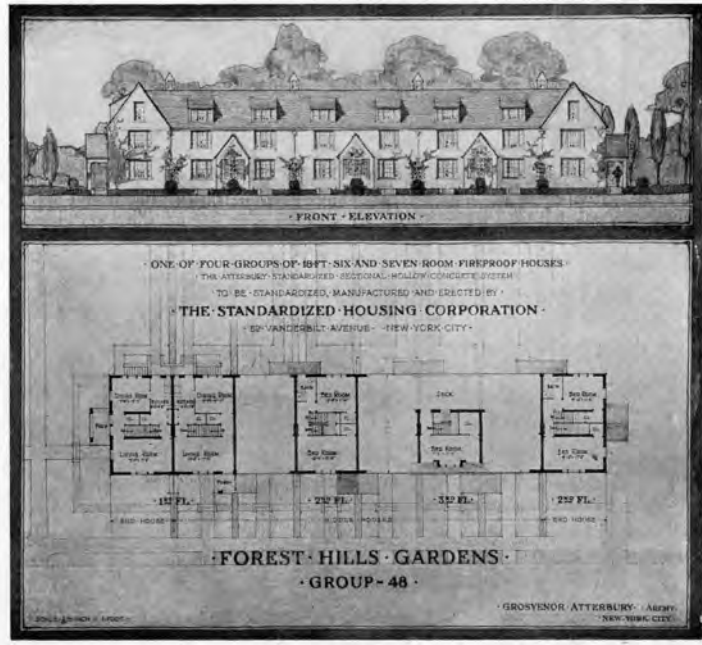
Taking Wall Blocks from Transfer Car. Group II, Forest Hills Gardens.



Setting Second Tier Wall Blocks, Showing Movable Electric Crane.

Fig. 57. Plates from Atterbury, *The Manufacture of Standardized Houses* showing the assembly of Group II, Forest Hills Gardens in 1912.

Source: Atterbury. *The Manufacture of Standardized Houses: A New Industry*. New York: Standardized Housing Corporation, 1918.



Proposed Group of Houses.
Standardized Hollow Concrete Construction.

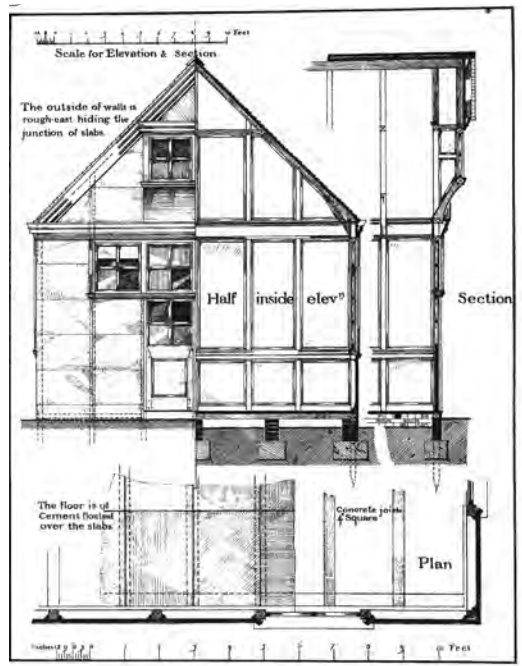
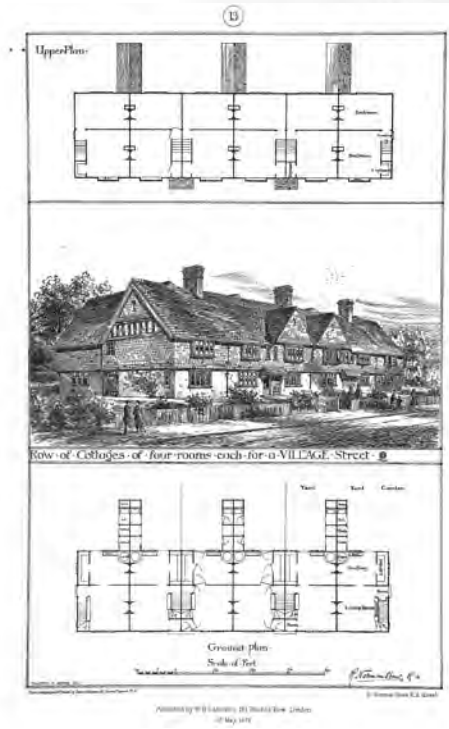


Fig. 58. Plate from Atterbury, *The Manufacture of Standardized Houses* showing plan and elevation of Group 48, Forest Hills Gardens, 1918 (top) and plates from Shaw, *Sketches for Cottages, Country Residences, and Other Buildings: Designed to Be Constructed in the Patent Cement Slab System of W. Lascelles*, showing a "row of cottages of four rooms each" (left) and set of details of Lascelles system, applied by Shaw (right). Sources: Atterbury. *The Manufacture of Standardized Houses: A New Industry*. New York: Standardized Housing Corporation, 1918; Norman Shaw, Ernest Newton. *Sketches for Cottages, Country Residences, and Other Buildings: Designed to Be Constructed in the Patent Cement Slab System of W. Lascelles*. London: B T Batsford, 1878.

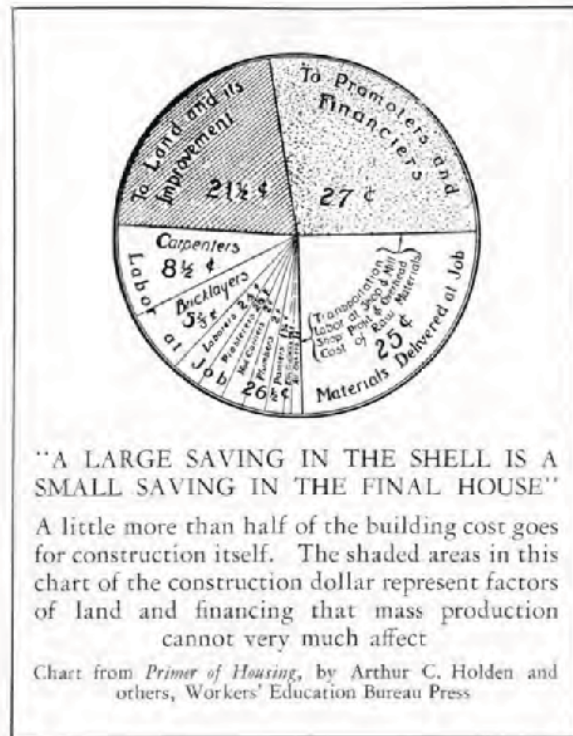


Fig. 59. Plate from Mumford, "Mass-Production and the Modern House" showing a pie-chart demonstrating that a "large saving in the shell is only a small savings in the final house".
 Source: Mumford. "Mass-Production and the Modern House." *The Architectural Record* (1930): 13-20.

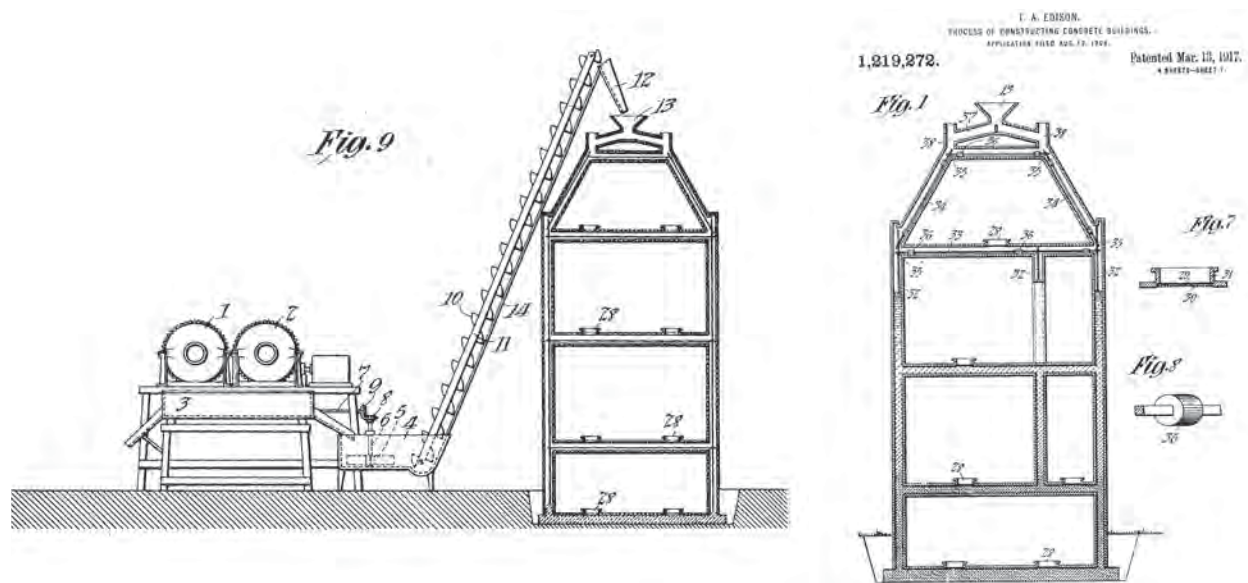


Fig. 60. T. A. Edison, patent for a "Process of Constructing Concrete Buildings" showing the significant mechanization required (left) and the complexity of the proposed molds (right).
 Source: US Patent 1,219,272

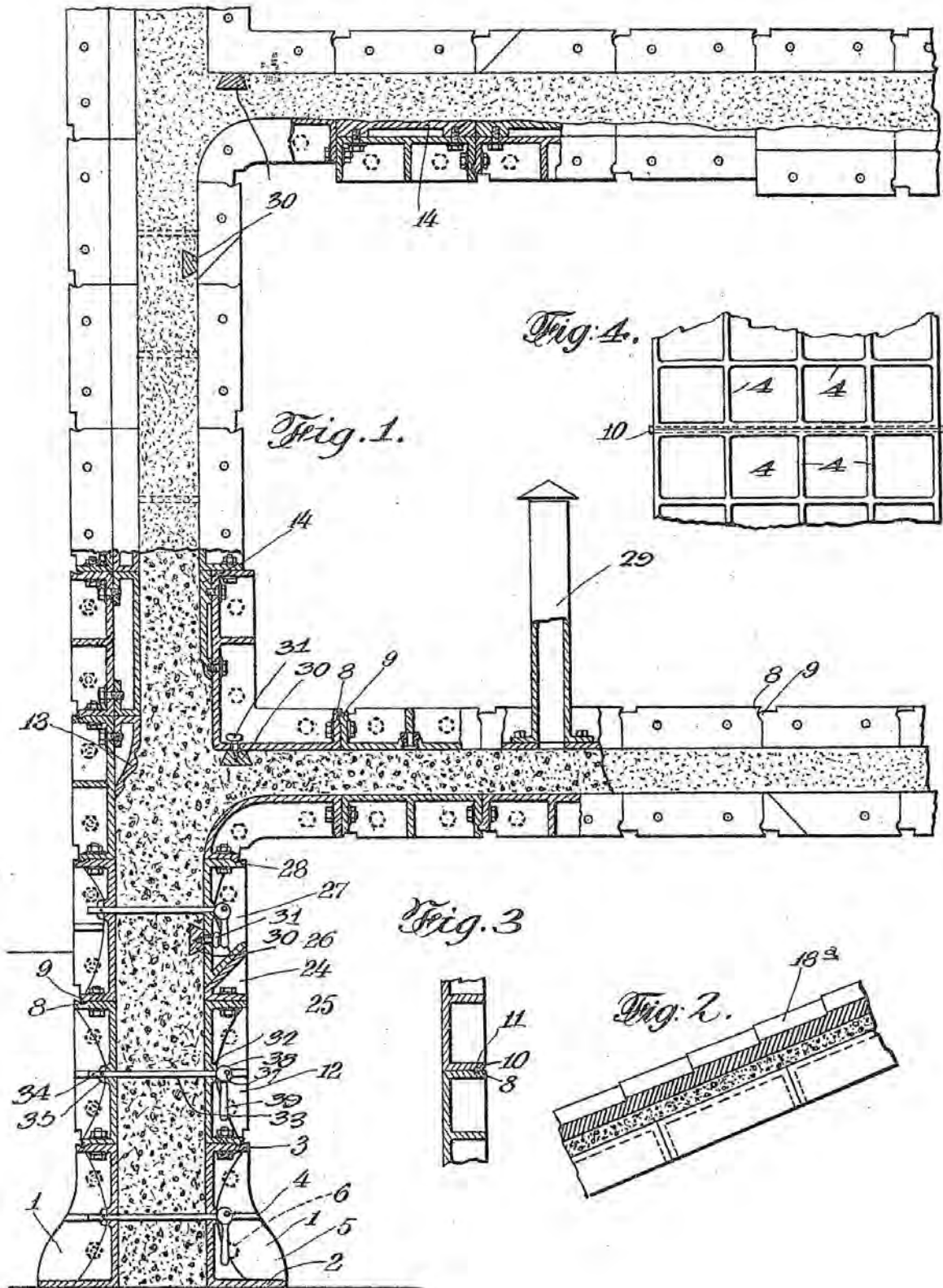


Fig. 61. H. J. Harms and G. E. Smalls, patent for a "molding apparatus for houses", reflecting the engineers experimentation and standardization work on modifying Edison's earlier proposal.
 Source: US Patent 1,187, 908.



FIG. 4—PLACING A SECTION OF THE PRE-CAST FLOOR.
The floor is pre-cast in units and assembled when the forms are placed.



FIG. 6—POURING A MONOLITHIC HOUSE.
The concrete, very wet, is hoisted to the platform, and emptied into a tank, from which it pours into the forms.



FIG. 5—THE FORMS ALL IN PLACE READY FOR POURING.
Note the runway to the mixer platform at the right of the building.



FIG. 7—REMOVING FORMS.
The flags are flying from the concrete tower. Indressed timber is used for scaffolding.

Fig. 62. Plates from Small, "Poured Houses in Holland", showing progress photos of the erection of molds and pouring of the first Harms-Small System unit, in Santpoort, Holland, in 1912.
Source: Small, George E. "Poured Houses in Holland." *Cement Age - Concrete Engineering* XIV, no. 2 (February, 1912): 63-67.

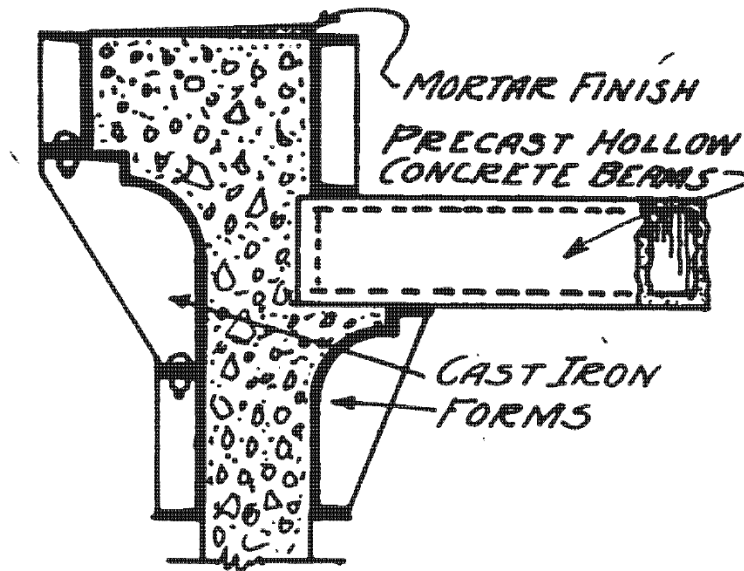


FIG. 15—DETAIL OF ROOF CONSTRUCTION

Fig. 63. Plate from Harms, "Building Concrete Industrial Houses by Harms System in France", showing the experimentally derived and standardized roof detail of the Harms Small System, 1916, generated through motion study, in order to resolve the casting sequence.

Source: Harms, Henry J. "Building Concrete Industrial Houses by Harms · System: Second Article Describes Layout of Work, Equipment and Methods Used." *Concrete* 12, no. 2 (February, 1918): 41-46.

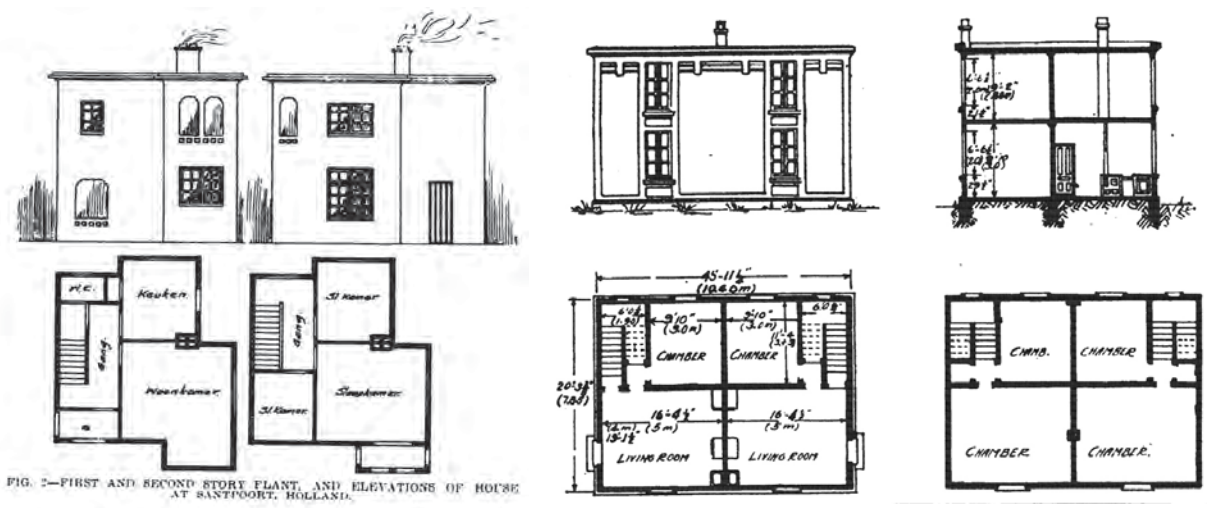


FIG. 2—FIRST AND SECOND STORY FLANT, AND ELEVATIONS OF HOUSE AT SANTPOORT, HOLLAND.



FIG. 1—THE COMPLETED HOUSE AT SANT-POORT, HOLLAND.
The concrete for this house was placed in one continuous six-hour pouring.

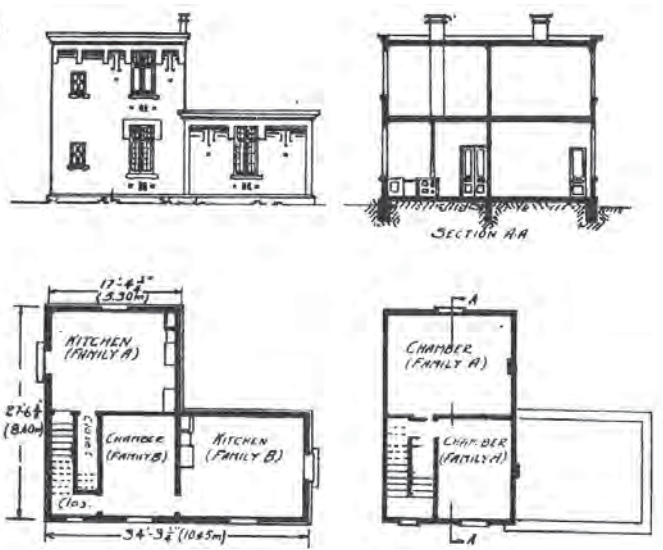


Fig. 64. Plates from Small, "Poured Houses in Holland", showing the unit developed through collaboration between Harms, Small, Hanna and Berlage (left) and plates from Harms, "Building Concrete Industrial Houses by Harms System in France", showing the applied ornamentation on the units in France.
Source: Small, George E. "Poured Houses in Holland." *Cement Age - Concrete Engineering* XIV, no. 2 (February, 1912): 63-67; Harms, Henry J. "Building Concrete Industrial Houses by Harms-System: Second Article Describes Layout of Work, Equipment and Methods Used." *Concrete* 12, no. 2 (February, 1918): 41-46.

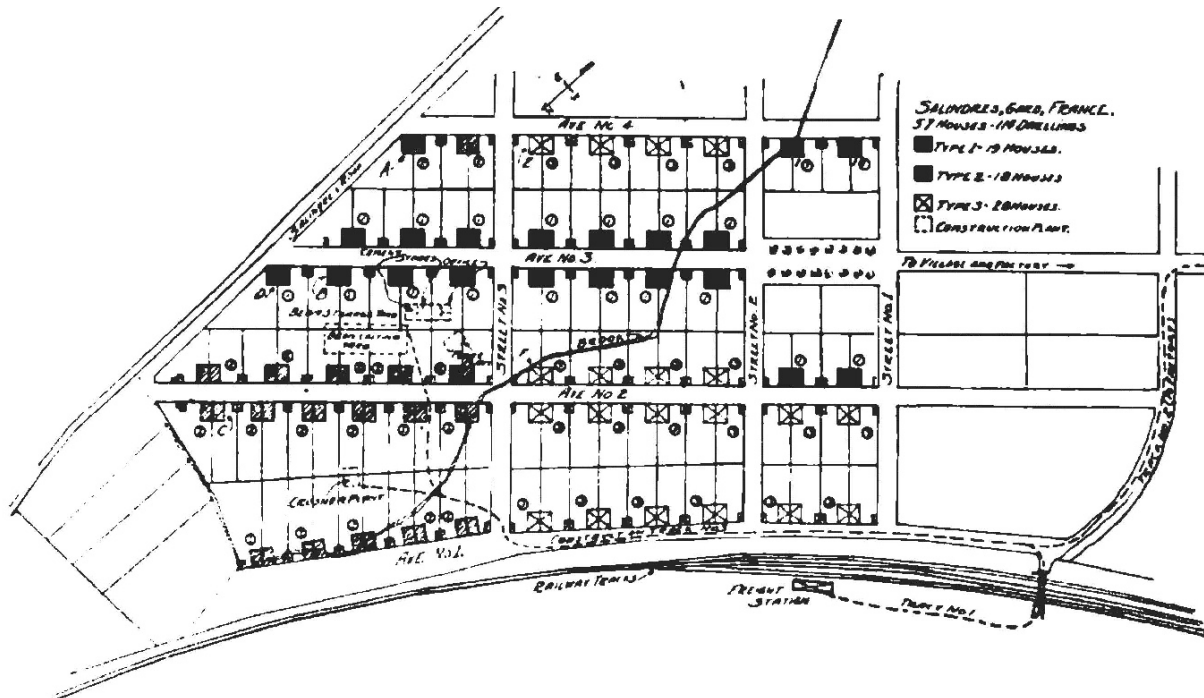


Fig. 65. Plate from Harms, "Building Concrete Industrial Houses by Harms System in France", showing "map of the group of concrete houses at Salindres" as well as the temporary construction plant plan, dashed. Source: Harms. "Building Concrete Industrial Houses by Harms-System: Second Article Describes Layout of Work, Equipment and Methods Used." *Concrete* 12, no. 2 (February, 1918): 41-46.



Fig. 66. Plates from Harms, "Building Concrete Industrial Houses by Harms System in France", showing two progress photos, taken one week apart, of pouring sequence along one of the street at Salindres (top) and view of the completed street (bottom). Source: Harms. "Building Concrete Industrial Houses by Harms-System: Second Article Describes Layout of Work, Equipment and Methods Used." *Concrete* 12, no. 2 (February, 1918): 41-46.

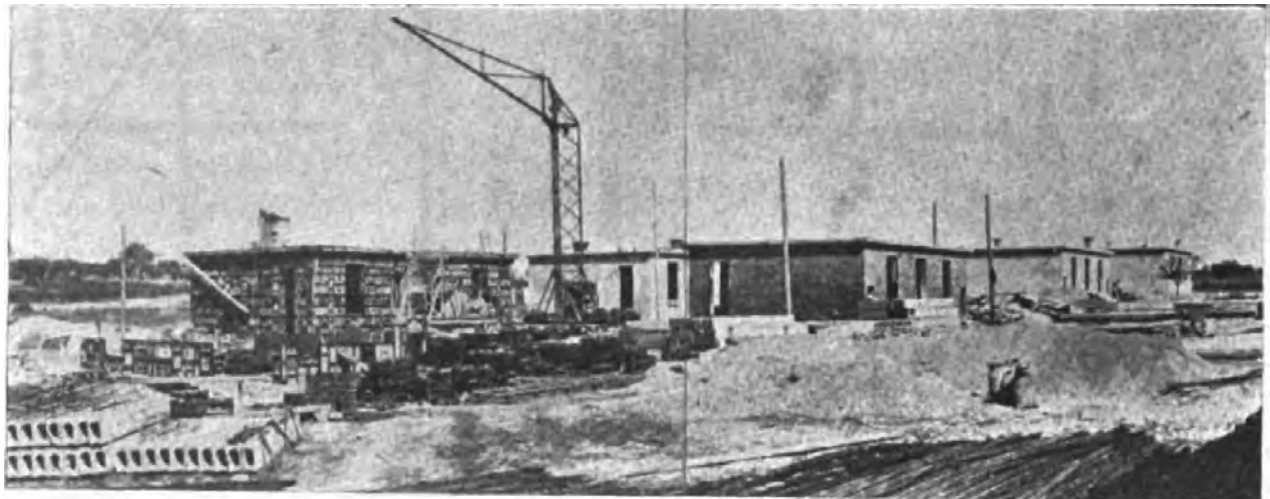
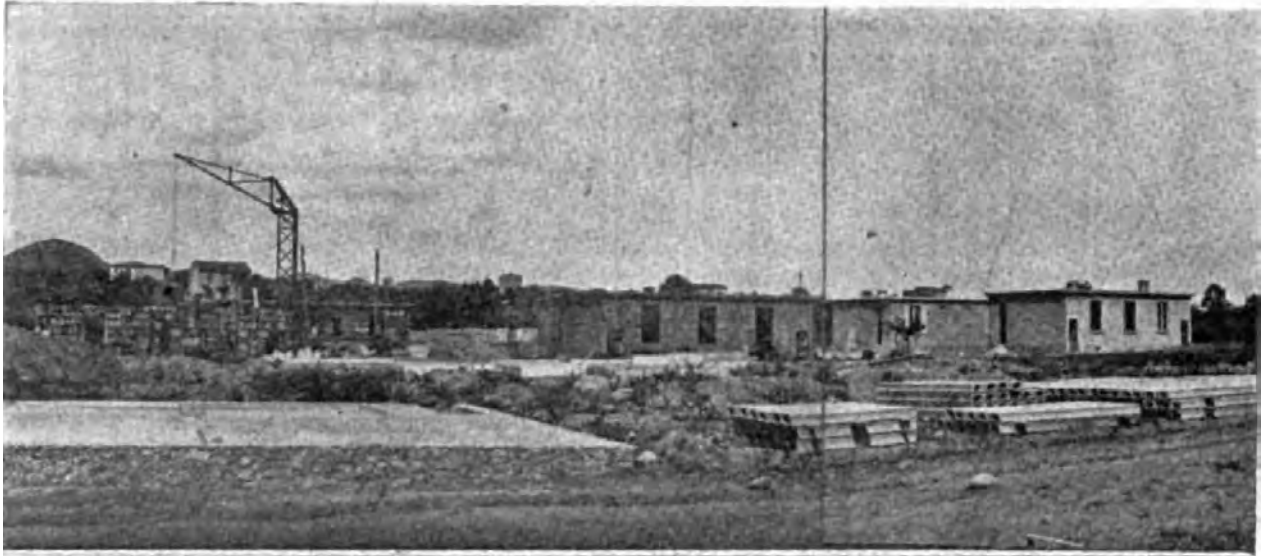


Fig. 67. Plates from Harms, "Building Concrete Industrial Houses by Harms System in France", showing two progress photos, taken one week apart, of the erection of molds, with precast floor beams, in foreground (top and middle) and view of the completed street (bottom).

Source: Harms. "Building Concrete Industrial Houses by Harms-System: Second Article Describes Layout of Work, Equipment and Methods Used." *Concrete* 12, no. 2 (February, 1918): 41-46.

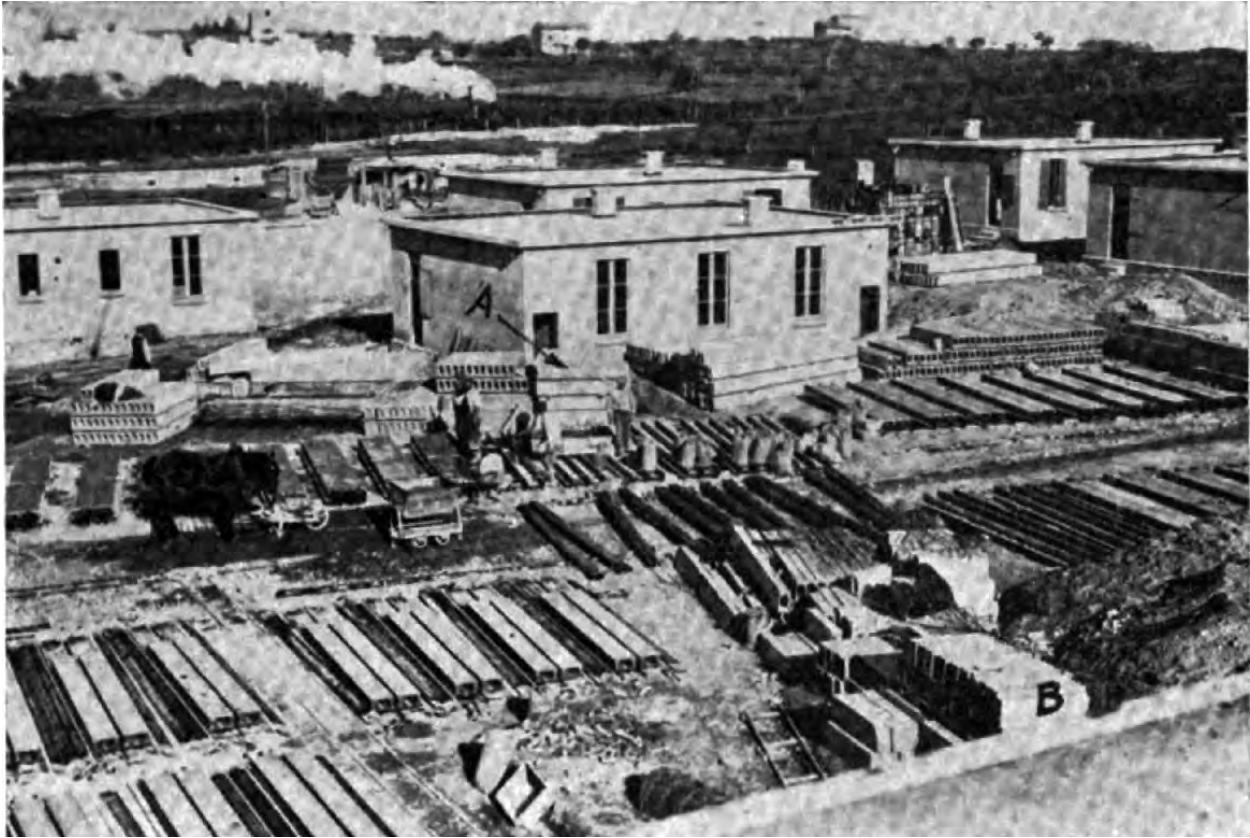
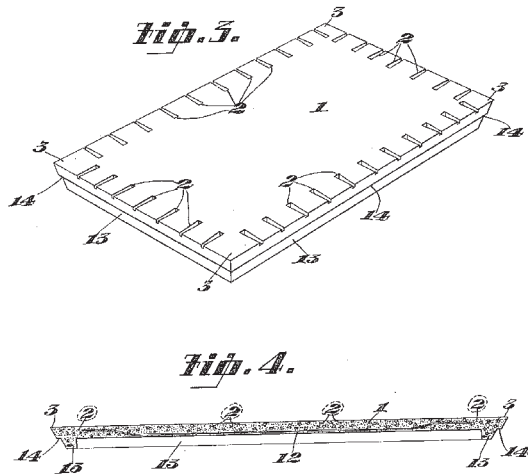
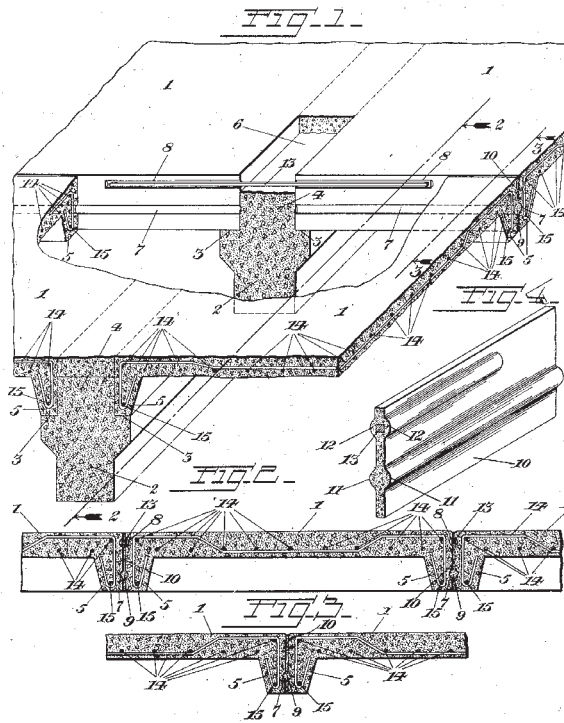


Fig. 68. Plate from Harms, "What French Industrial Dwellings Cost", showing "general view of beam yard, showing stages of fabrication", indicated by the sequence of letters from A, B.
Source: Harms, Henry J. "What French Industrial Dwellings Cost." *Concrete* 12, no. 3 (March, 1918): 78-81.

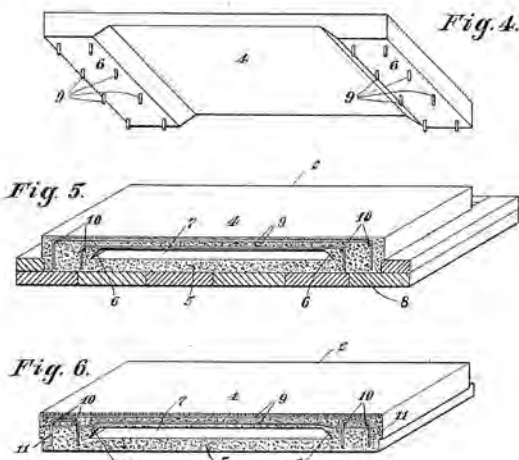
962,078. CONCRETE CONSTRUCTION. APPLICATION FILED JAN. 9, 1909. Patented June 21, 1910. 2 SHEETS—SHEET 2.



992,734. CONCRETE CONSTRUCTION. APPLICATION FILED APR. 14, 1910. Patented May 16, 1911.



1,079,112. WALL CONSTRUCTION. APPLICATION FILED AUG. 7, 1912. Patented Nov. 18, 1913. 2 SHEETS—SHEET 1.



1,031,045. SYSTEM OF REINFORCEMENT FOR CONCRETE SLABS. APPLICATION FILED APR. 27, 1912. Patented July 2, 1912. 5 SHEETS—SHEET 1.

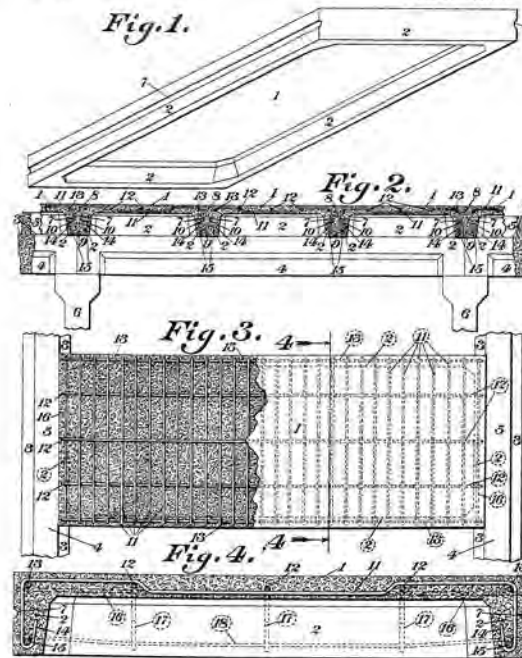


Fig. 69. J. Conzelman's Unit System, Patents for Concrete Construction (1910, 1911), Wall Construction (1913) and System of Reinforcement for Concrete Slabs (1912), showing the relative simplicity of fabrication and assembly logics, as compared to the Atterbury System or the Harms-Small System. Sources: US Patents 962,078, 992,734, 1,079,112, 1,031,045.

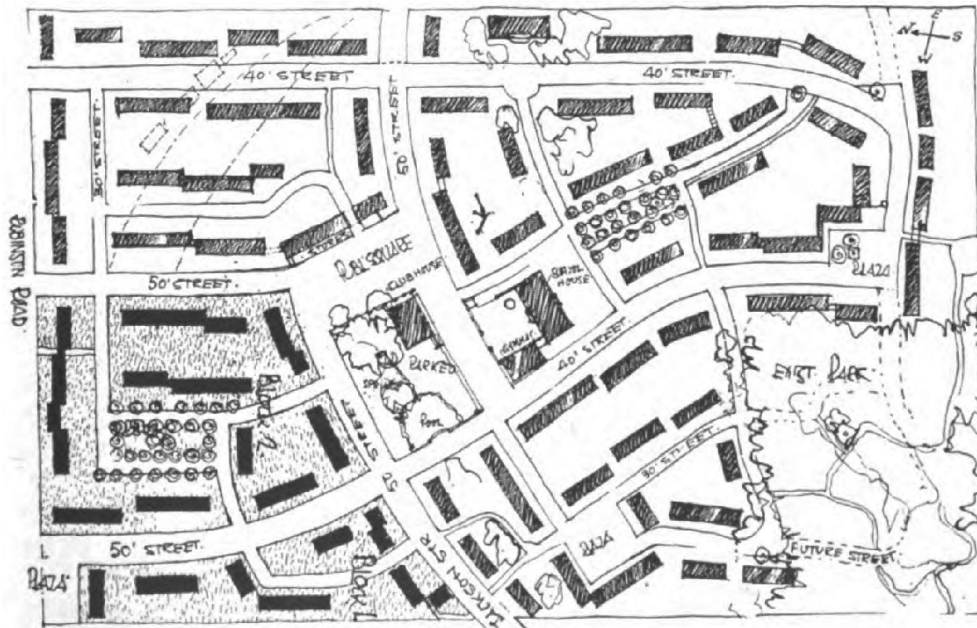


FIG. 9.—LAYOUT OF HOUSING SCHEME FOR YOUNGSTOWN SHEET & TUBE CO. SHADED PORTION SHOWS PART UNDER CONTRACT—FAINT DOTTED LINES ABOVE INDICATE LAYOUT OF CONSTRUCTION PLANT

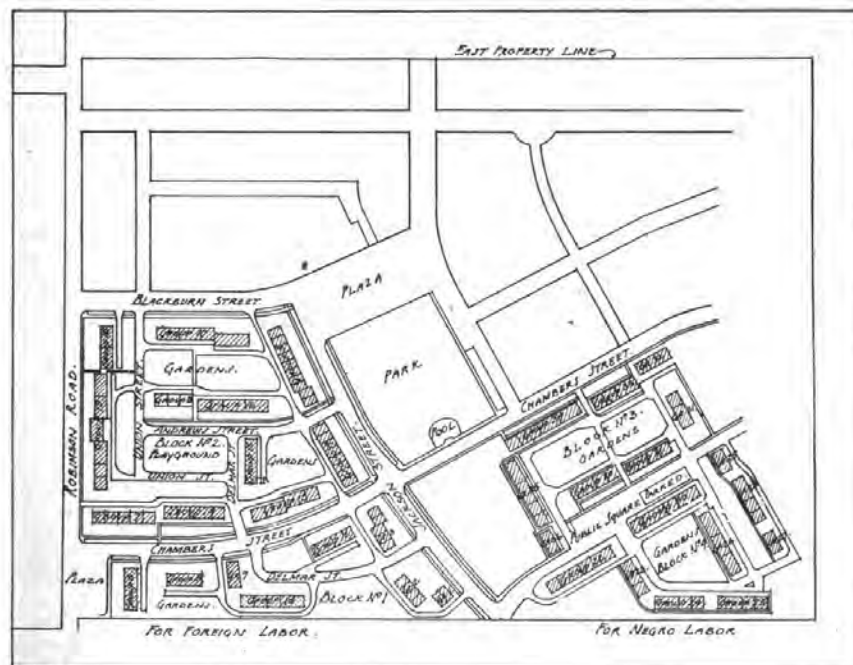


Fig. 70. Plate from Whipple, "146 Unit-Built Concrete Dwellings at Youngstown", showing Conzelman, Herding and Boyd's settlement scheme for the Youngstown Sheet & Tube Co., in 1917, with the temporary construction plant indicated with a dashed line and the first planned phase hatched (top) and plate from Whipple, "281 Fireproof Dwellings Built of Large Precast Concrete Units", showing Conzelman, Herding and Boyd's settlement scheme for the Youngstown Sheet & Tube Co., in 1918, with units indicated (bottom).

Sources: Whipple, Harvey. "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co." *Concrete* 12, no. 1 (January 1918): 5-9; "281 Fireproof Dwellings Built of Large Precast Concrete Units." *Concrete* 14, no. 1 (1919): 3-8.

CONCRETE

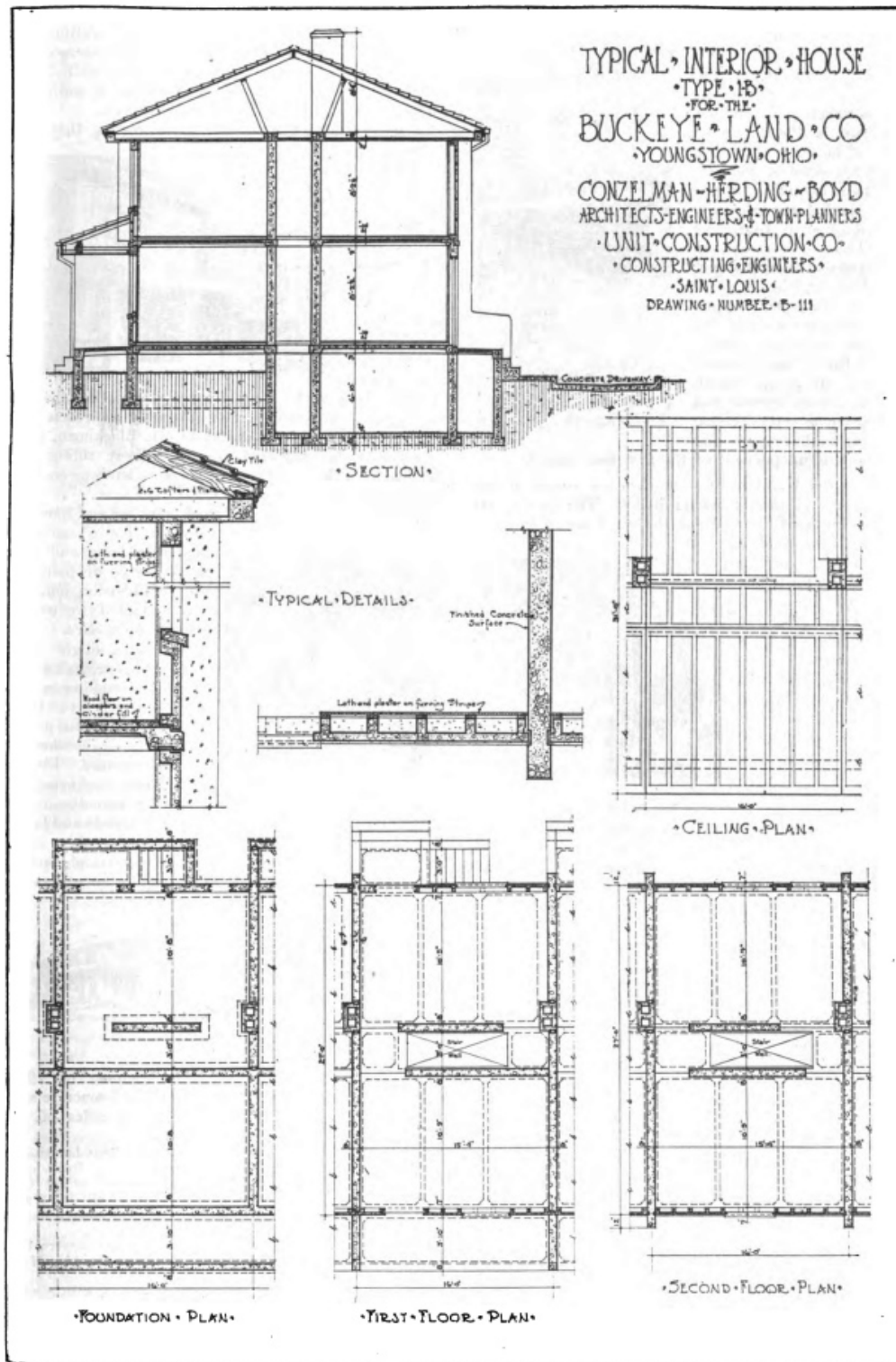


Fig. 71. Plate from Whipple, "281 Fireproof Dwellings Built of Large Precast Concrete Units", showing the basic type, a single family row-house, at Youngstown, adapted from the patents shown in Fig. 69
 Sources: "281 Fireproof Dwellings Built of Large Precast Concrete Units." *Concrete* 14, no. 1 (1919): 3-8.

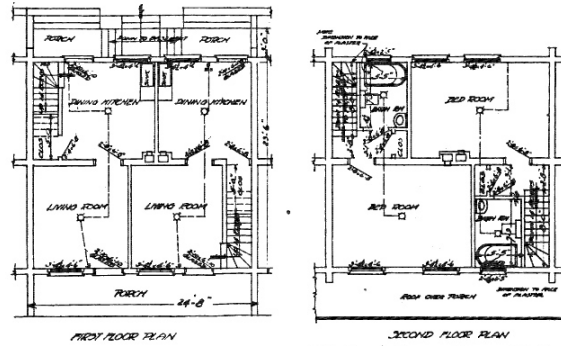
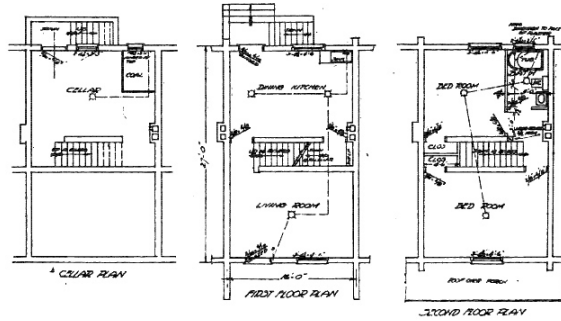


FIG. 4—A AND B—TYPICAL FLOOR PLANS. (A) SINGLE FAMILY UNIT. (B) DOUBLE HOUSE. (C) SEE NEXT PAGE—TRIPLE FAMILY UNIT

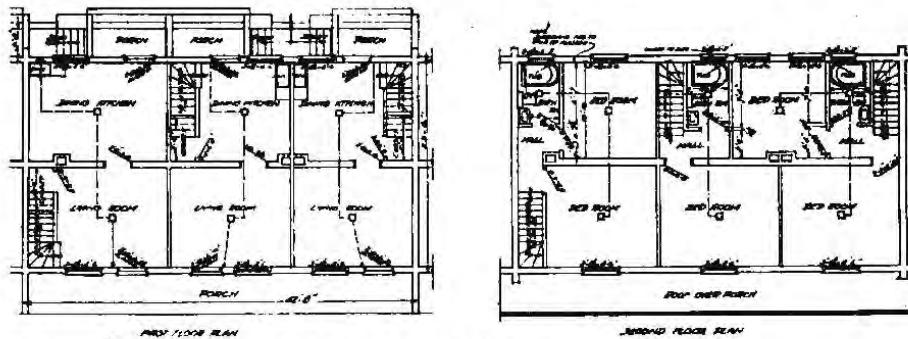


FIG. 4—(C) FLOOR PLANS, THREE-FAMILY TERRACE



FIG. 5—FROM DRAWING TO SHOW COMPLETED APPEARANCE OF A GROUP OF UNIT BUILT DWELLINGS

Fig. 72. Plates from "146 Unit-Built Concrete Dwellings at Youngstown", showing plans of single, double and triple family units (top and middle) and a perspective, prepared by Herding and Boyd, of one of the groupings (bottom).

Source: Whipple. "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co." *Concrete* 12, no. 1 (January 1918): 5-9

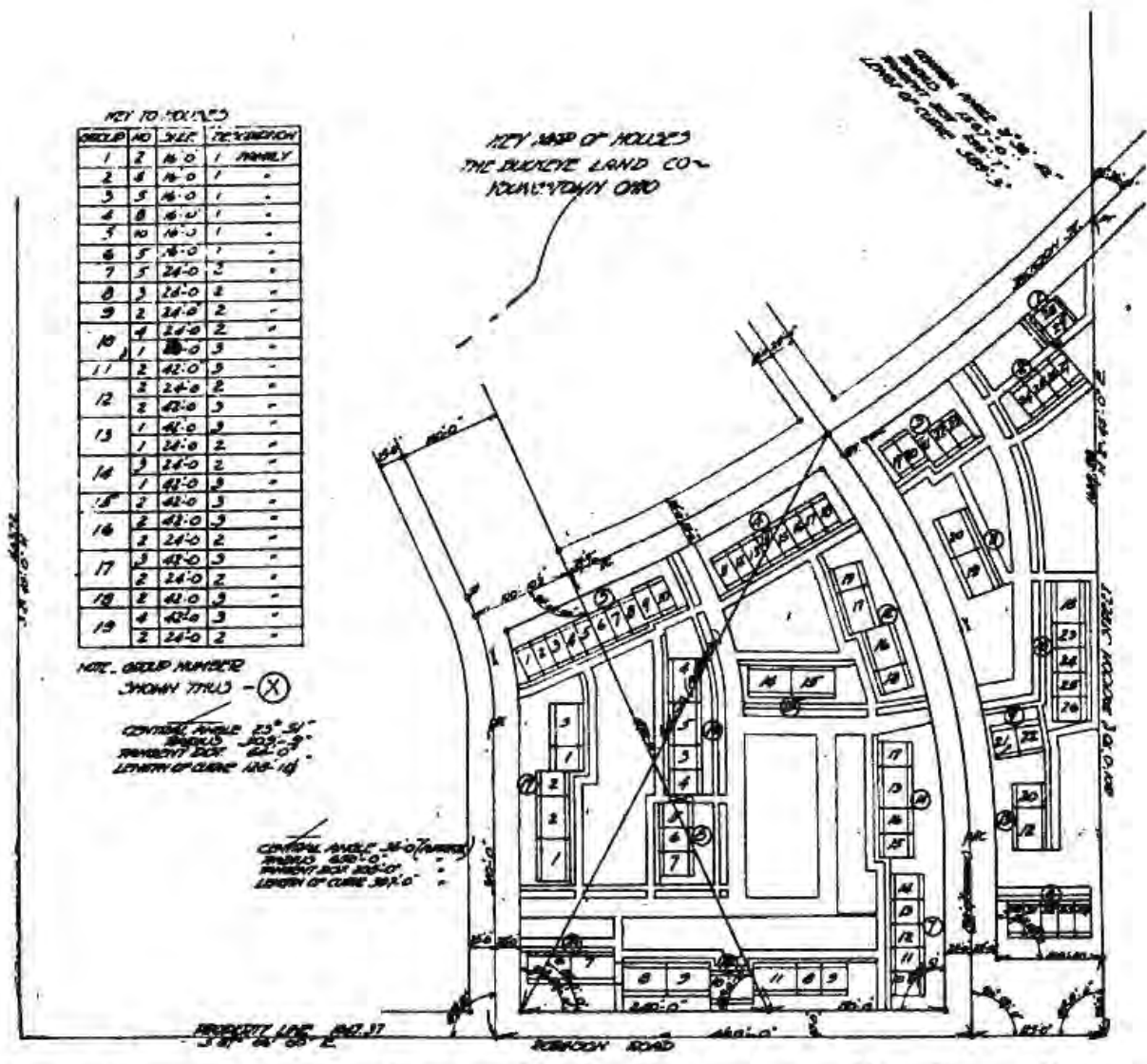


FIG. 8—DETAIL LAYOUT OF PART OF HOUSING DEVELOPMENT NOW UNDER CONTRACT WITH SCHEDULE OF ACCOMMODATION IN FAMILIES PER BUILDING

Fig. 73. Plates from "146 Unit-Built Concrete Dwellings at Youngstown", showing "detail layout of part of housing development now under contract with schedule of accommodation in families per building". Compare to Fig. 18.
 Source: Whipple. "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.". *Concrete* 12, no. 1 (January 1918): 5-9



FIG. 6—CASTING YARD; TRACK FOR LOCOMOTIVE CRANE AT LEFT; CASTING AREA AND TRAMWAY AT RIGHT WITH TOWER IN BACKGROUND

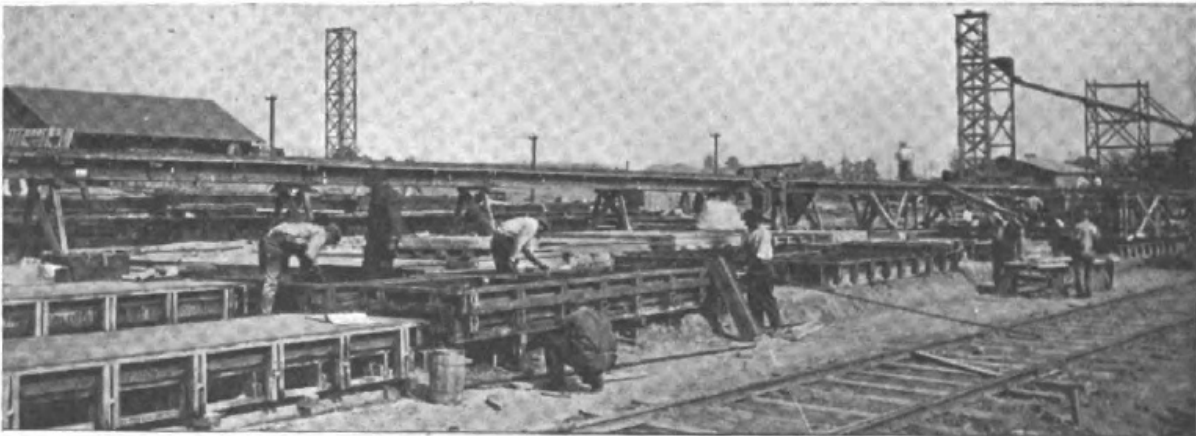


FIG. 7—A NEAR VIEW OF MOLDS FOR UNIT SLABS

Fig. 74. Plates from "146 Unit-Built Concrete Dwellings at Youngstown", showing the organization of the temporary construction plant at Youngstown.

Source: Whipple. "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.". *Concrete* 12, no. 1 (January 1918): 5-9



FIG. 8—CRANE TAKING UNIT OF SIDE WALL FROM CASTING AREA

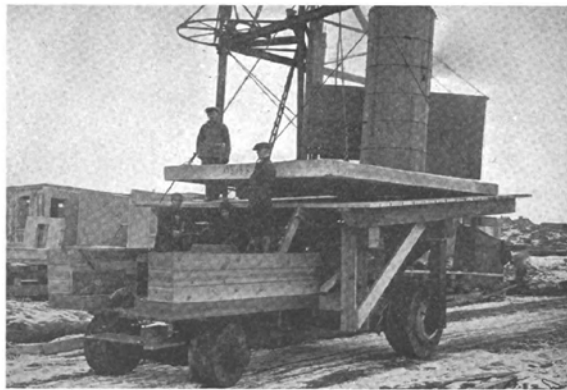


FIG. 9—HOIST TAKING SLAB FROM THE "BUS"

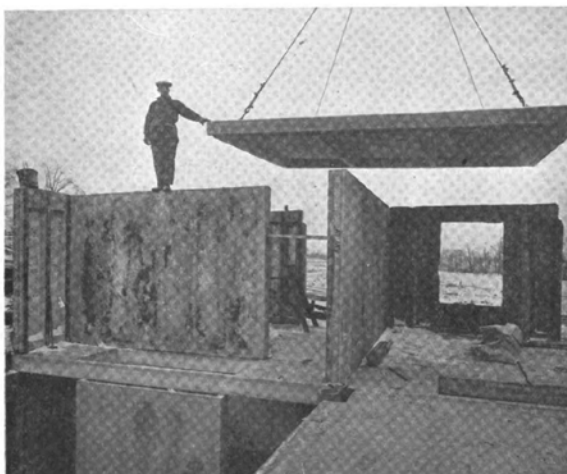


Fig. 75. Plates from "146 Unit-Built Concrete Dwellings at Youngstown", showing the assembly of a typical row house using the Unit System.

Source: Whipple. "146 Unit-Built Concrete Dwellings at Youngstown: Housing Enterprise for Youngstown Sheet Tube Co., by Unit Construction Co.". *Concrete* 12, no. 1 (January 1918): 5-9

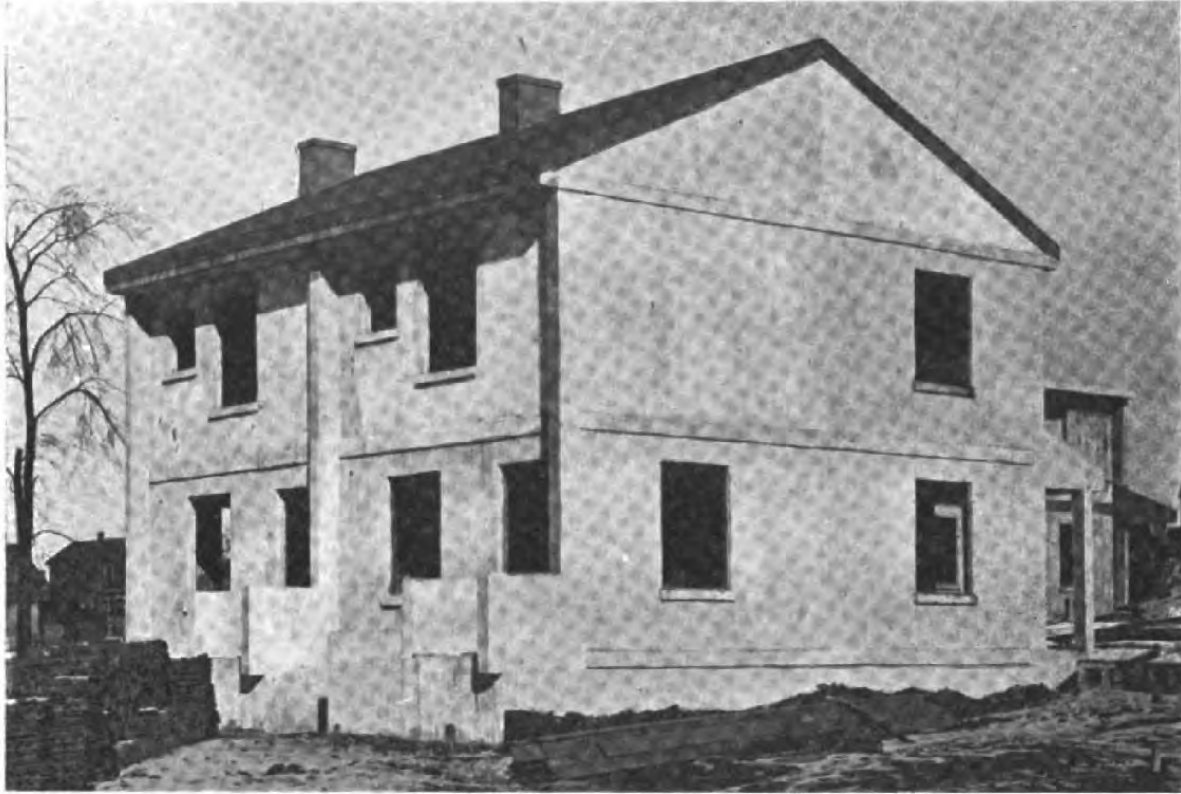


FIG. 1—THE DOUBLE UNIT BUILT HOUSE, NEAREST COMPLETION—REAR VIEW



Fig. 76. Plates from "281 Fireproof Dwellings Built of Large Precast Concrete Units", showing a photograph of the first pair of row-houses completed at Youngstown, prior to the addition of mass produced building components, such as windows and gutters (top) and photograph of a group of row-house units, after the mass produced components were added (bottom). Compare to Figs. 149 and 167.
Source: "281 Fireproof Dwellings Built of Large Precast Concrete Units." *Concrete* 14, no. 1 (1919): 3-8.

Chapter 4: Figures

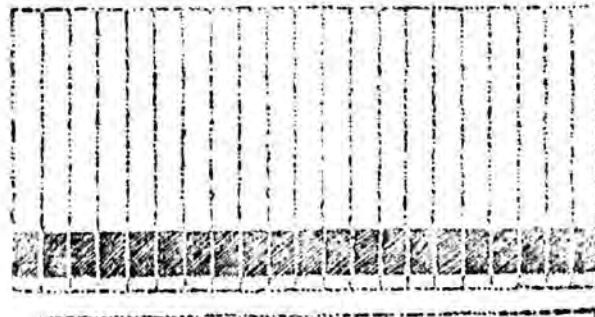
Bei 40 qm bebauter Fläche und 200 qm Gartenland für jedes Grundstück werden von der gleichen Straßenlänge (105 m) erschlossen:



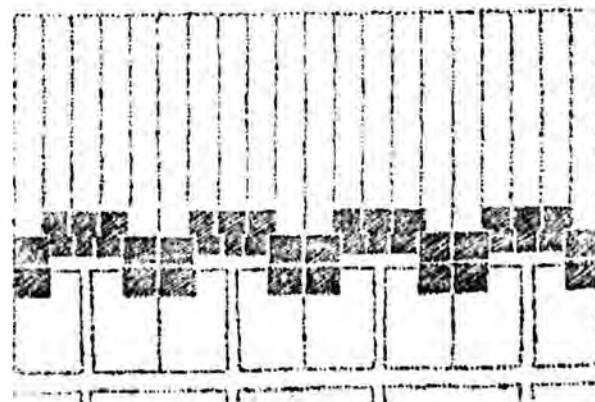
beim Einzelhausbau
7 Häuser
Blocklänge 35 m



beim Doppelhausbau
14 Häuser
Blocklänge 26 m



beim Reihenhausbau
21 Häuser
Blocklänge 106 m



beim Gruppenhausbau
28 Häuser
Blocklänge 134 m

Abb. 4

Fig. 77. Plate from Behrens, *Toward Economical Building*, comparing single family, duplex, row-house and grouped building method approaches.

Source: Peter Behrens, Heinrich de Fries. *Vom Sparsamen Bauen: Ein Beitrag Zur Siedlungsfrage*. [Toward Economical Building: A Contribution to the Settlement Question] Berlin: Verlag der Bauwelt, 1918. 25.

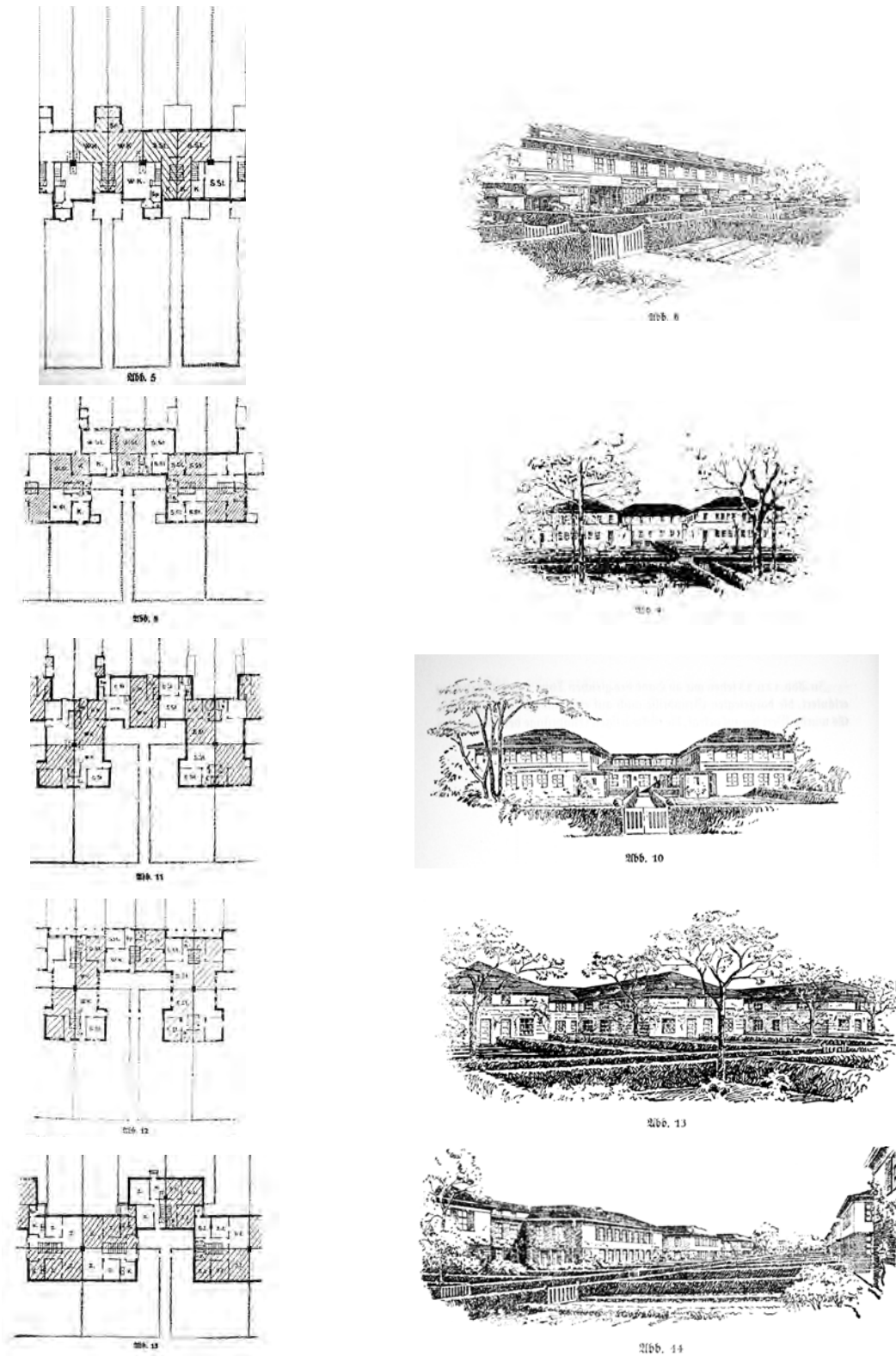


Fig. 78. Plates from Behrens, *Toward Economical Building*, showing plans and perspective views of grouped building method Types I-IV.

Source: *Vom Sparsamen Bauen*, 1918. 39, 41, 43, 44, 45, 46, 47, 48, 49.

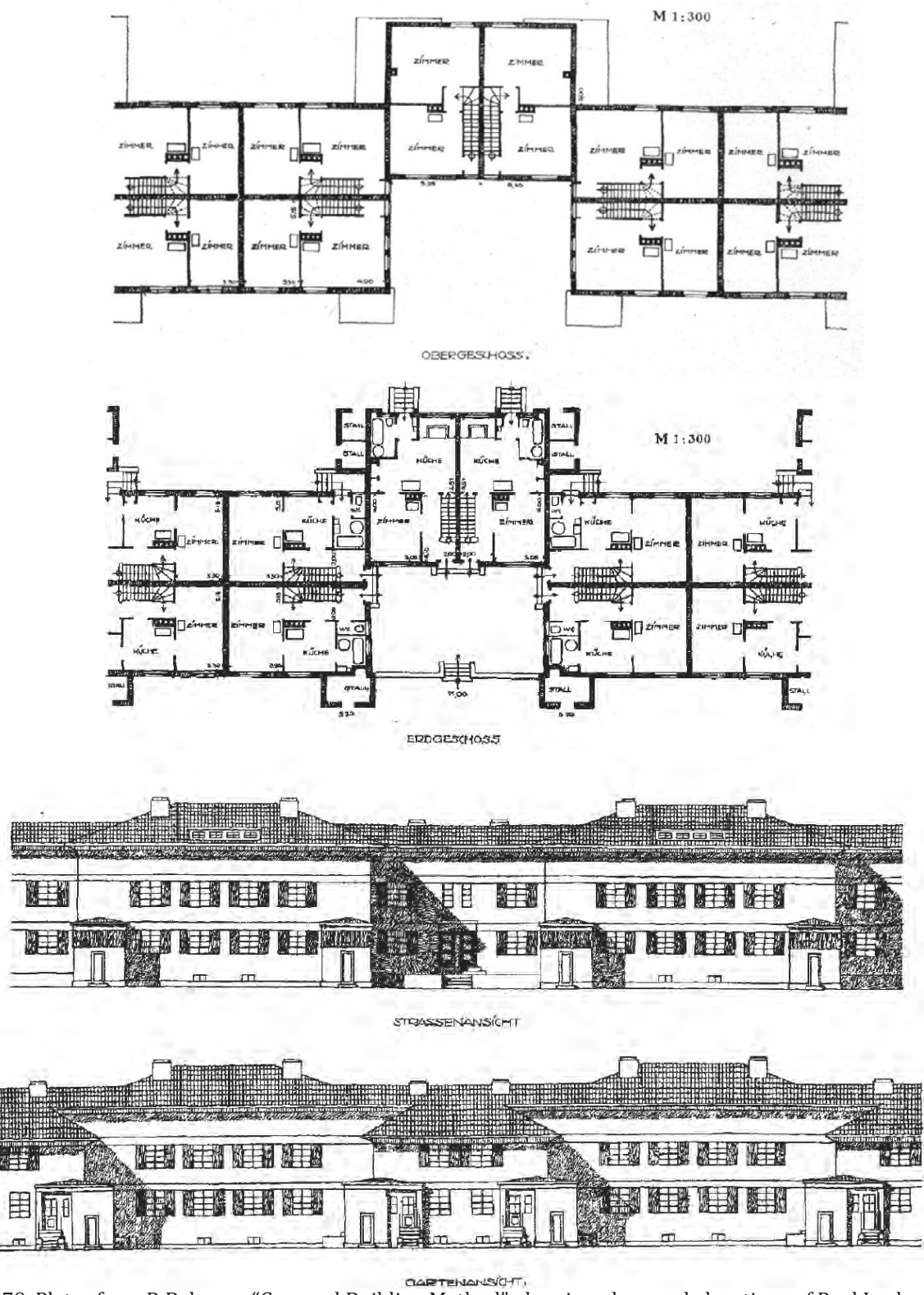


Fig. 79. Plates from P. Behrens, "Grouped Building Method", showing plans and elevations of Paul Jordan Strasse housing (1918-19).
 Source: Behrens, Peter. "Die Gruppenbauweise." [Grouped Building Method] *Wasmuths* (1919): 122-27.

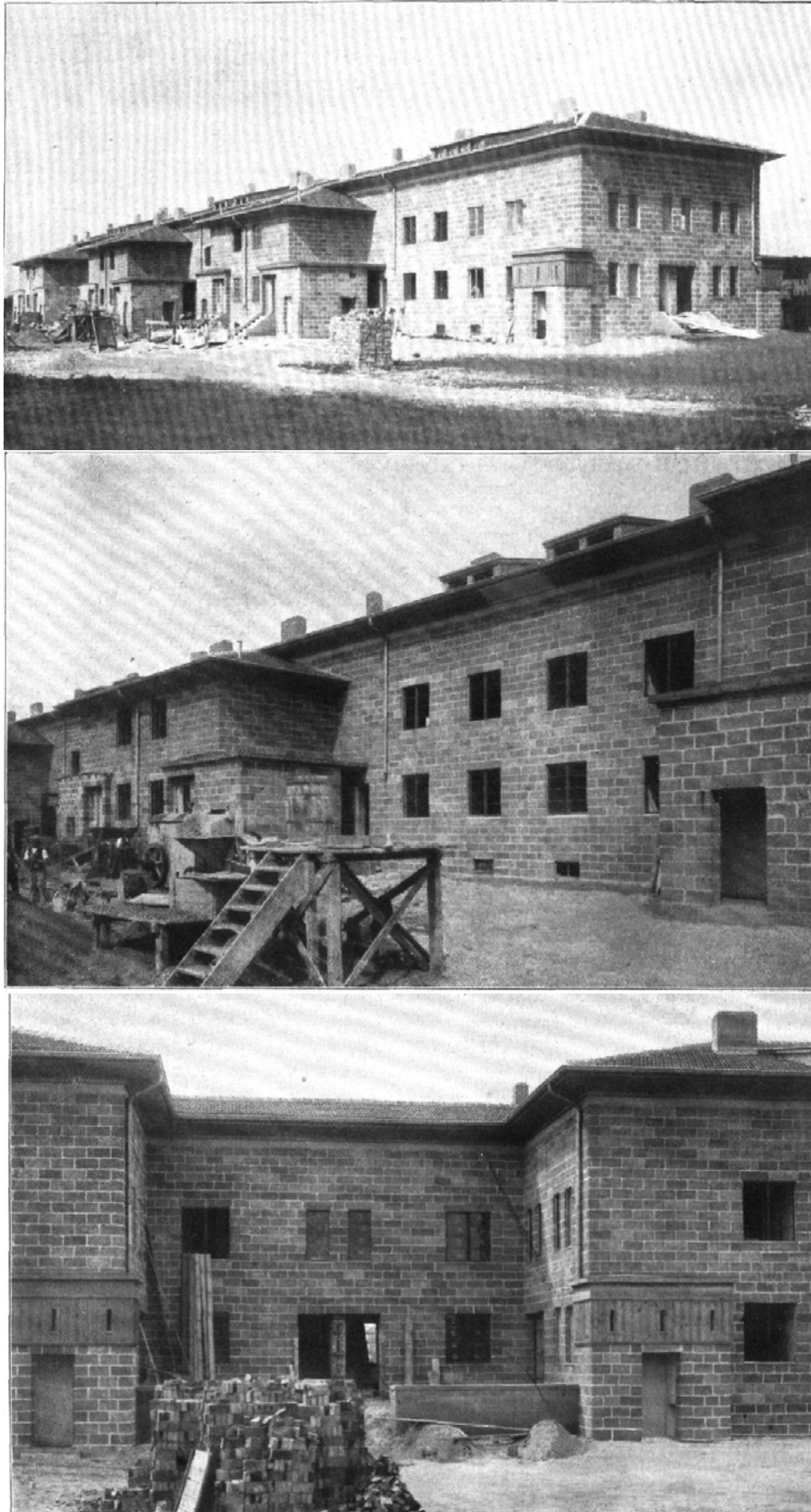


Fig. 80. Plates from P. Behrens, "Grouped Building Method", showing photographs of Paul Jordan Strasse housing (1918-19), under construction.

Source: Behrens, Peter. "Die Gruppenbauweise." [Grouped Building Method] *Wasmuths* (1919): 122-27.

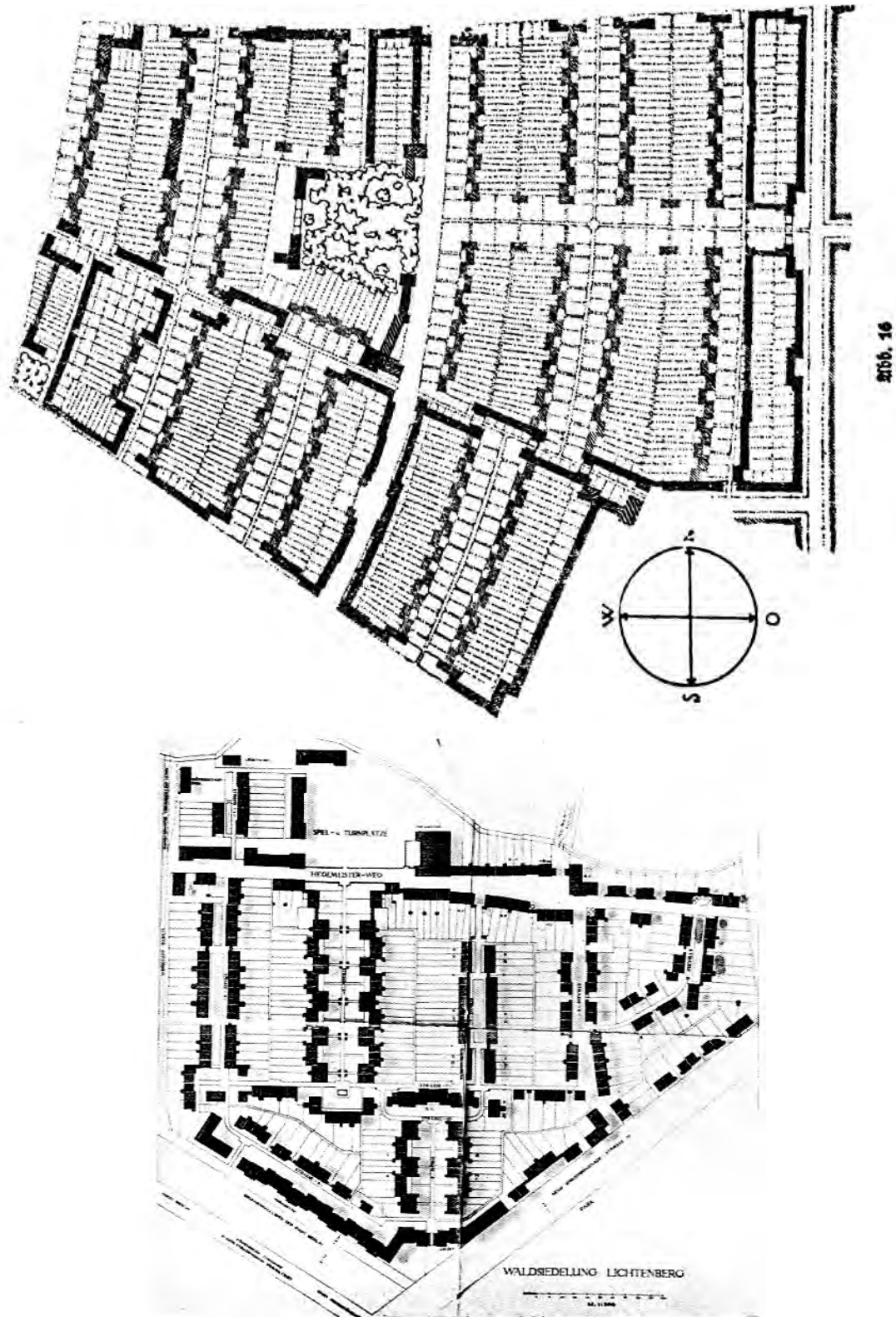


Fig. 81. Plate from Behrens, *Toward Economical Building*, showing Hennigsdorf Settlement proposal (top) and plate from P. Cremers, Peter Behrens, showing Lichtenberg Settlement proposal (bottom).
 Sources: *Vom Sparsamen Bauen*, 1918. 75; Cremers, Paul Joseph. *Peter Behrens*. Essen: Baedeker, 1928. 129.

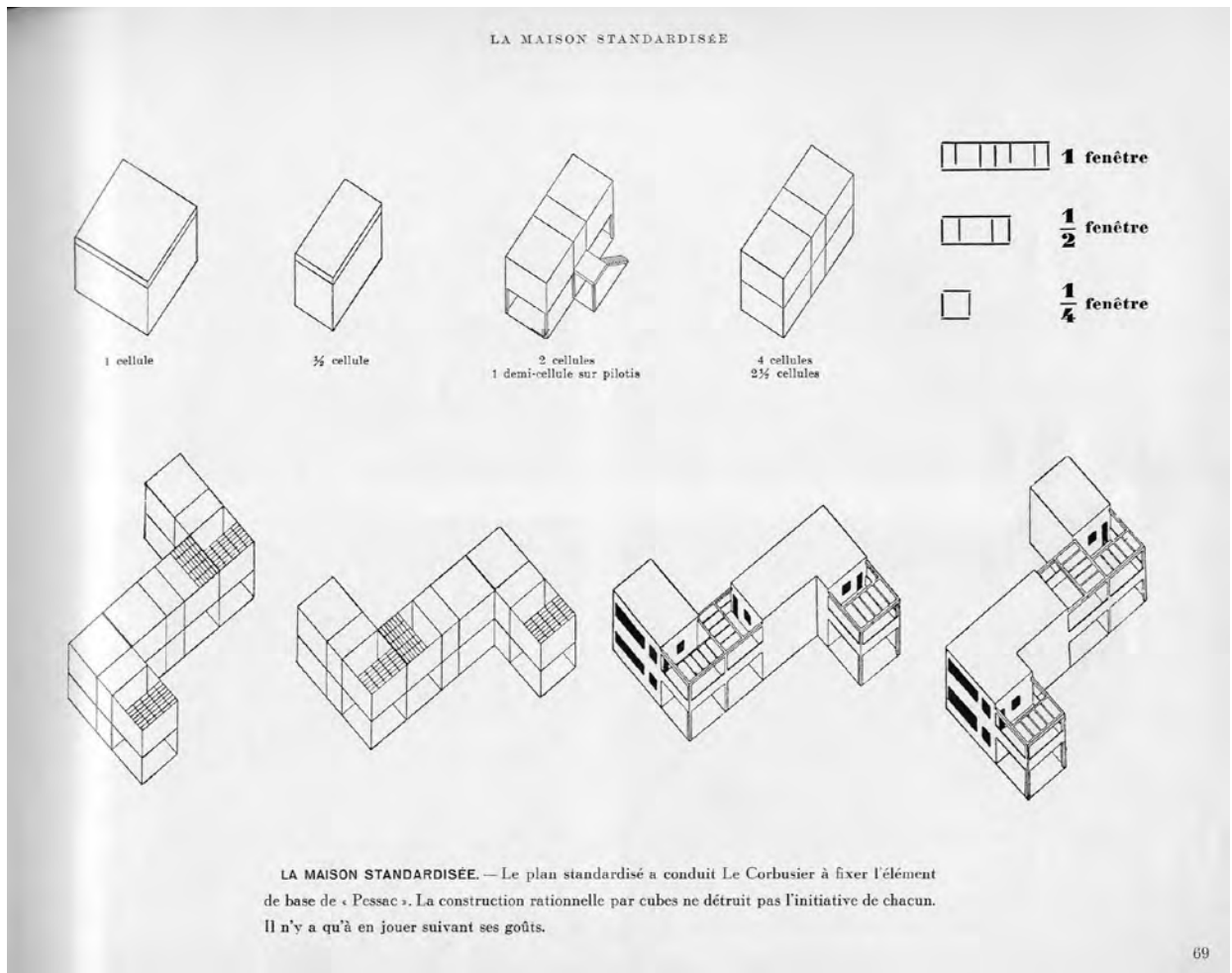
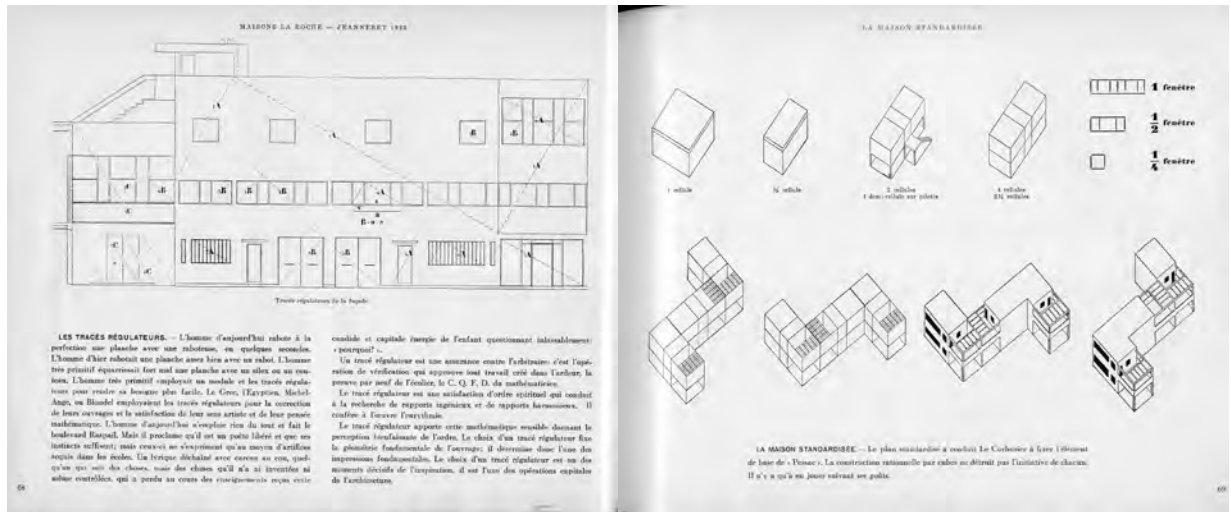
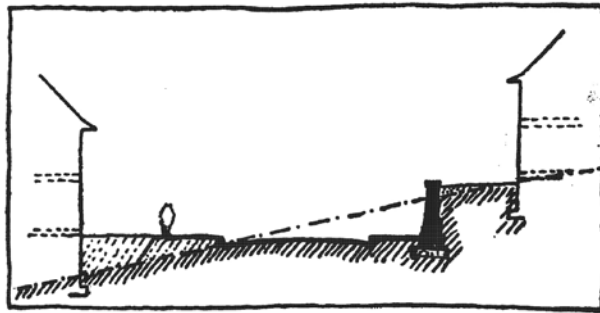
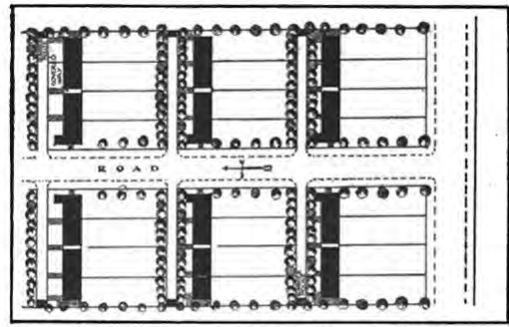


Fig. 82. Plates from Le Corbusier, *Oeuvre Complete*, showing “regulating lines” (left) and a “standardized villa” (right).

Source: Le Corbusier, P. Jeanneret. *Oeuvre Complete* 1910-1929. Paris: W. Boesiger et O. Stonorov, 1936. 68-69.



Illus. 224.—Cross-section of a road on hillside. The chain lines show the actual level of the ground.



Illus. 230.—Diagram showing arrangement of groups of houses at right angles to a road to secure a southern aspect.



Illus. 233.—Verona. Castel S. Pietro.

Fig. 83. Plates from *Town Planning in Practice* showing cross section of a hillside, diagram showing arrangement of groups of houses at right angle to a road to secure a southern aspect and an example of this approach (Verona, Italy).

Source: Unwin. *Town Planning in Practice*. 1909. 301, 314, 315.



Fig. 84. Le Corbusier. Study for Garden City Cretets, 1914.

Source: FLC 30267 "Etude D'une Cite Jardin Aux Cretets Plan De Parcellement 1 E."

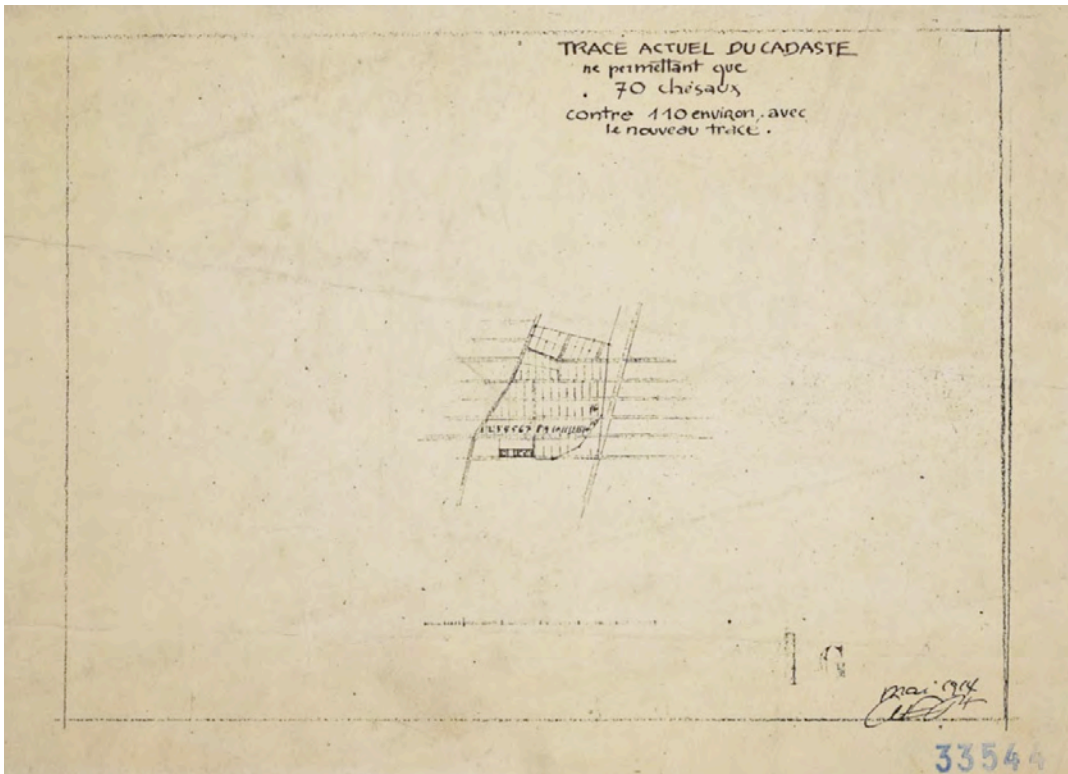


Fig. 85. Le Corbusier. "Drawing of the current site parcelling which permits 70 lots as opposed to the 110 lots afforded by the new scheme", 1914.

Source: FLC 33544 "Trace Acutel du Cadaste"



Fig. 86. Le Corbusier. "First model for the creation of a Garden City on the Cretets site", 1914.

Source: FLC 30268 "Premiere Maquette Pour La Creation d'une Cite Jardin aux Cretets plan de proprietarie M Beck, May 19, 1914."

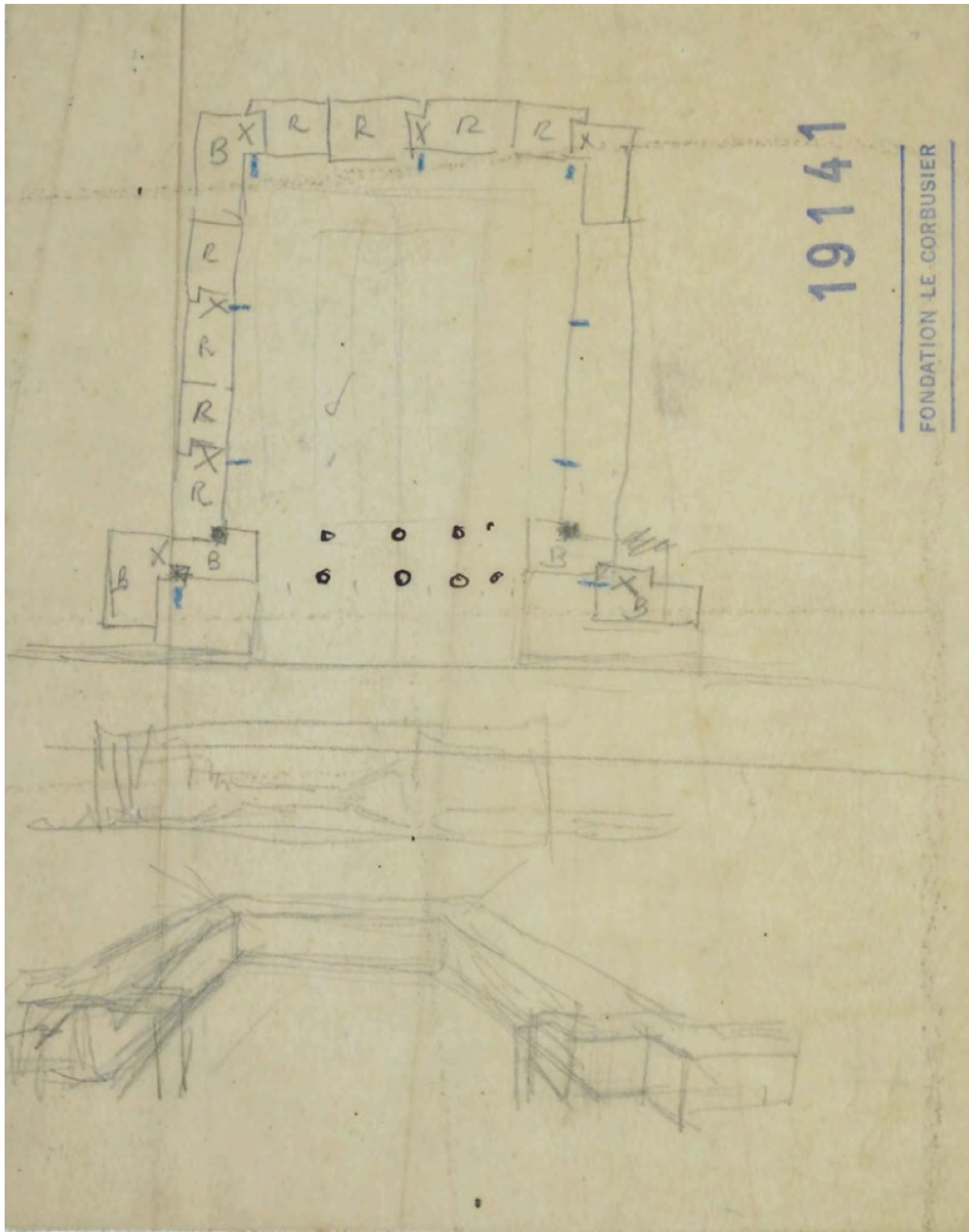


Fig. 87. Le Corbusier. Plan, perspective and birds-eye-view perspective study of Domino System, 1914. Compare with Fig. 88.
Source: FLC 19141

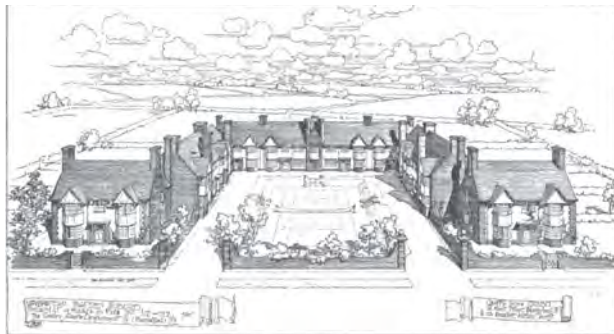
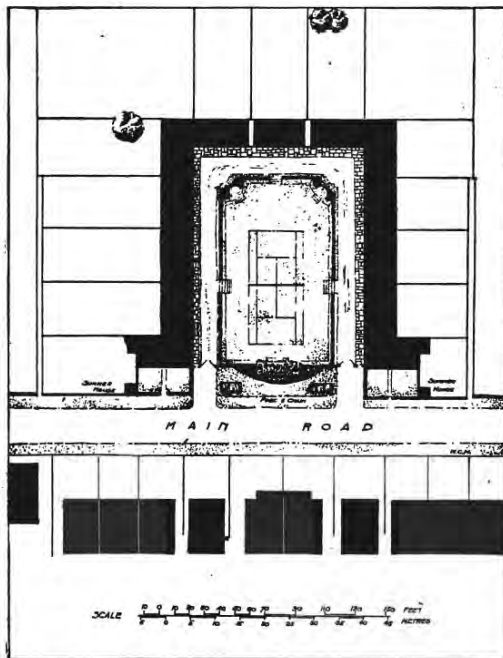


Abb. 33. Garden Suburb Hampstead. Großer Wohnhof, Hampstead-Way, Architekt: Geoffrey Lucas, A. R. I. B. A.



Illus. 277.—Hampstead Garden Suburb. Quadrangle of houses with carriage drives circling tennis-court, built for the Hampstead Tenants, Limited. See Illus. 292.

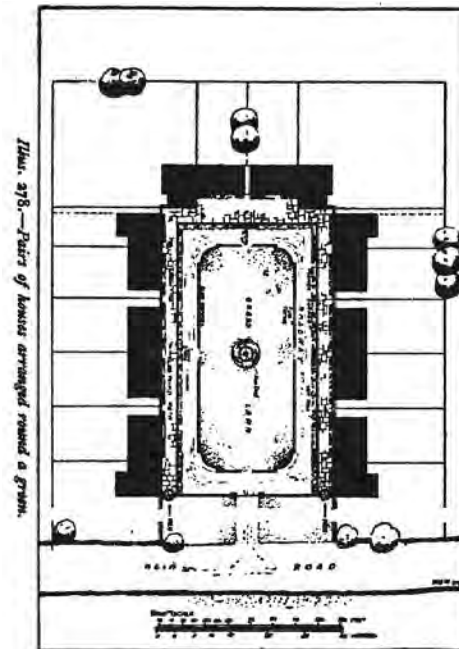


Fig. 88. Photograph of Parker and Unwin's Quadrangle on Hampstead Way (1907) (top), plate from Berlepsch, "Hampstead" and photograph showing Geoffrey Lucas's Lucas Square, Hampstead (1907) (middle) and plates from Town Planning in Practice showing two variants of a quadrangle organizational scheme (bottom). Sources: Harvard Art Museums/Fogg Museum, 3.2002.1745.1, 3.2002.1745.2; Berlepsch. "Hampstead— Eine Studie Über Städtebau in England [Hampstead – a Study of High City Building in England]." *Kunst und Kunst-handwerk* 12 (1909): 241-84; Unwin. *Town Planning in Practice*, 1909. 354, 355.

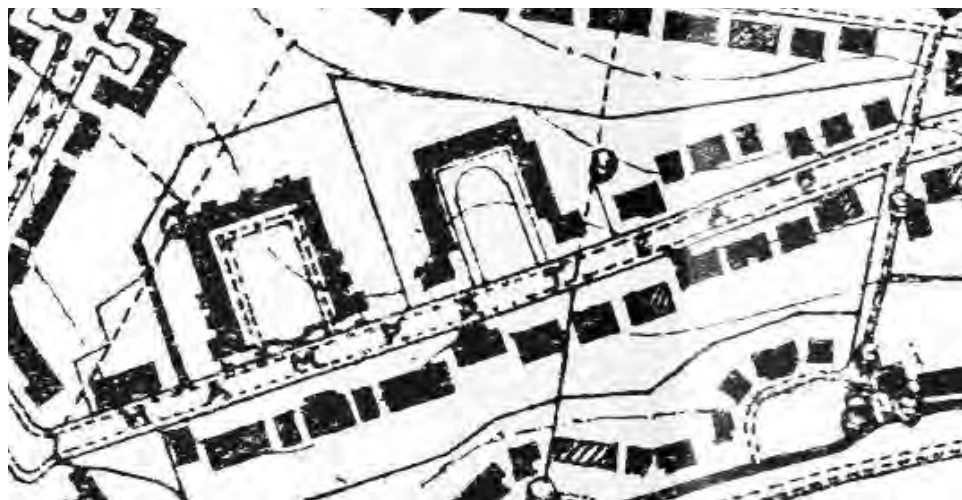
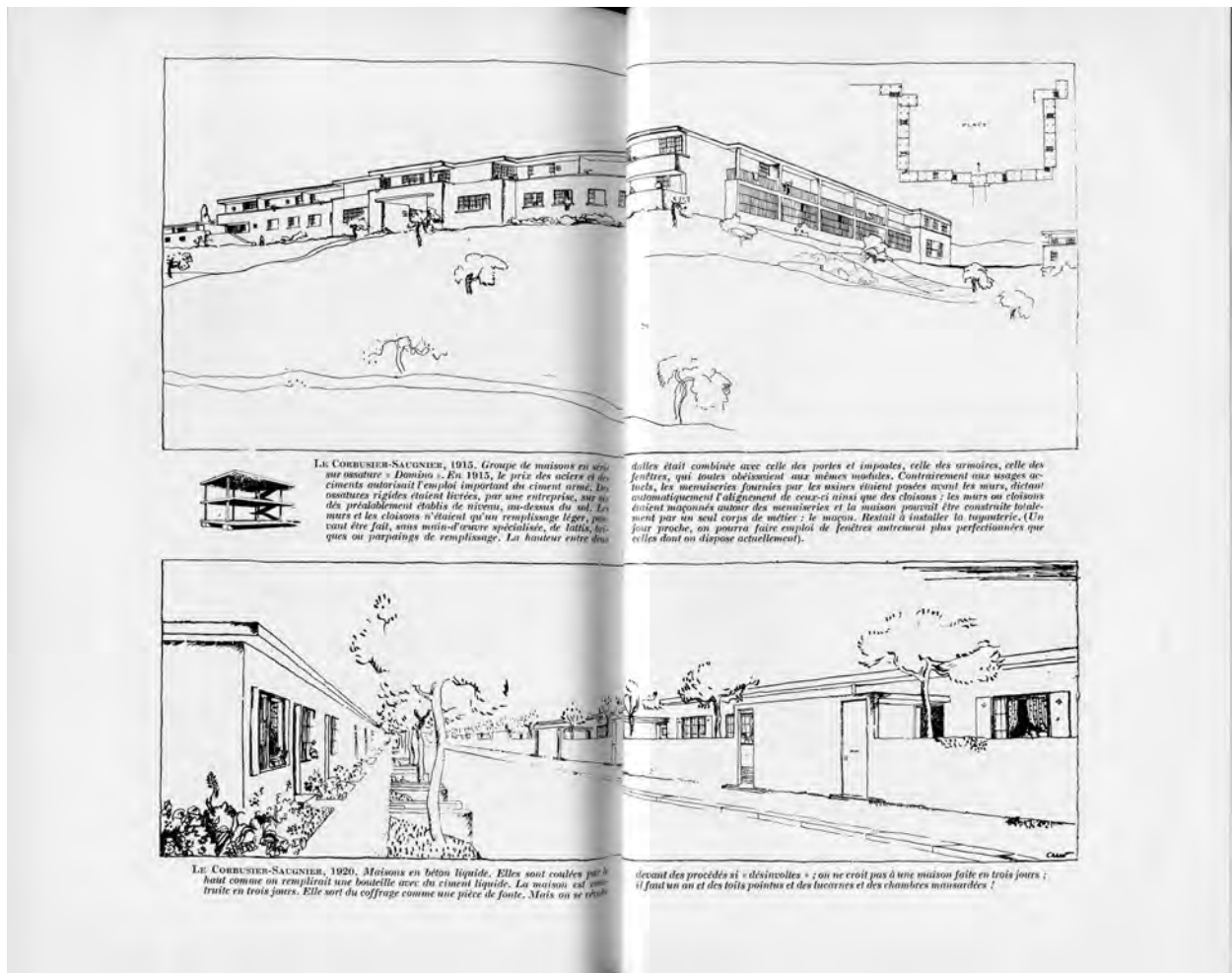


Fig. 89. Spread from “Maisons En Série” showing “group of houses in series in Domino frames”, organized in a quadrangle, a Domino frame, and “houses of liquid concrete” (top) and portion of the 1909 Hampstead plan showing the Quadrangle on Hampstead Way and Lucas Square in relation to the street and topography (bottom).

Sources: Corbusier, Le. “Maisons En Série.” *L'Esprit Nouveau* 13 (1922): 1525-42; Unwin. *Town Planning in Practice*, 1909. Appendix.

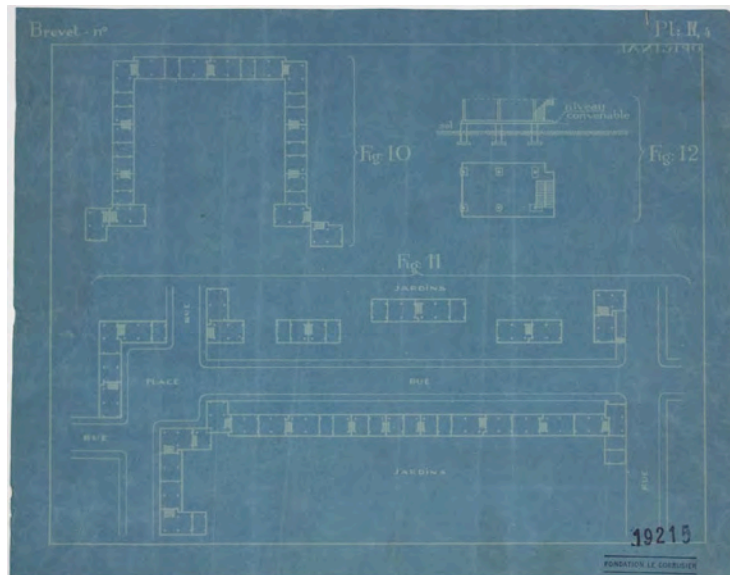
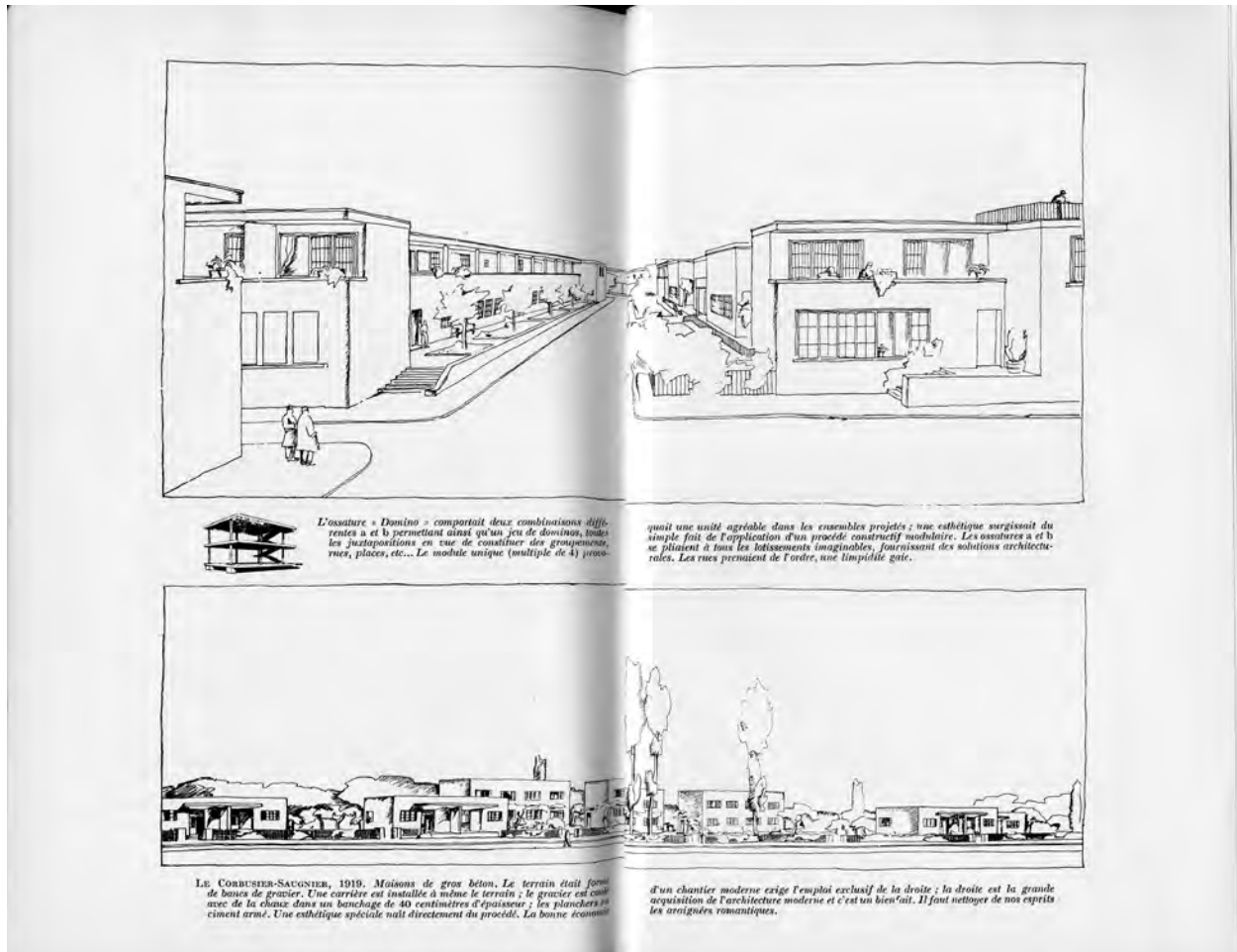


Fig. 90. Spread from “Maisons En Série” showing Domino frames grouped to form a street, a Domino frame and “houses of massive concrete” (top) and a sheet from Le Corbusier’s 1916 patent for the Domino System (bottom). Compare to Fig. 49.

Sources: Corbusier, Le. “Maisons En Série.” *L’Esprit Nouveau* 13 (1922): 1525-42; FLC 19215.

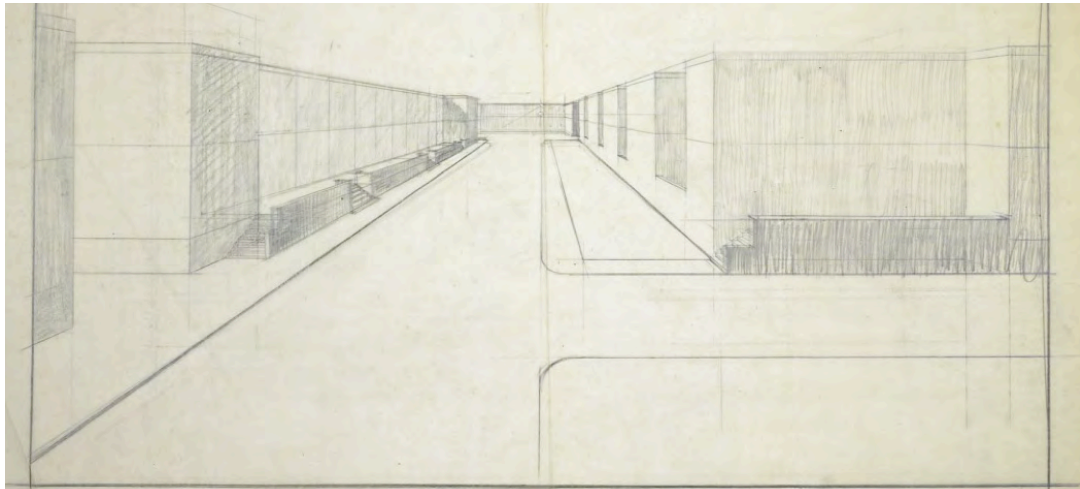
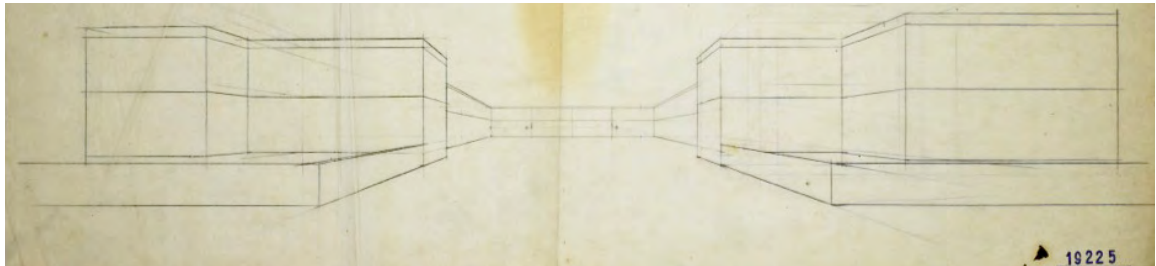
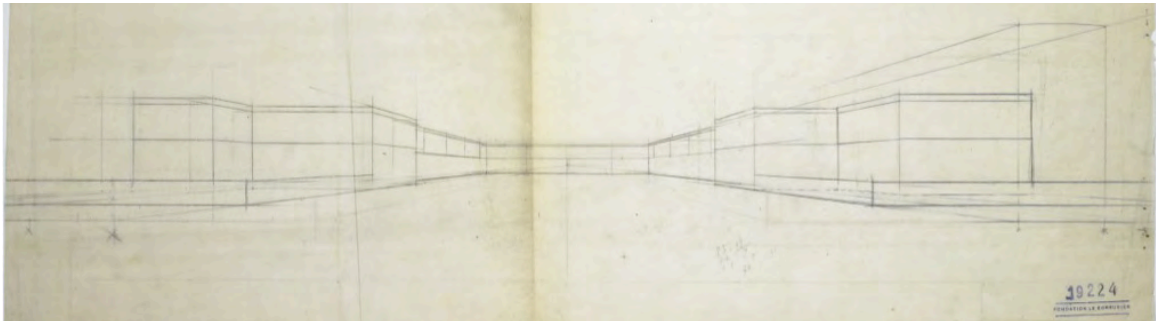
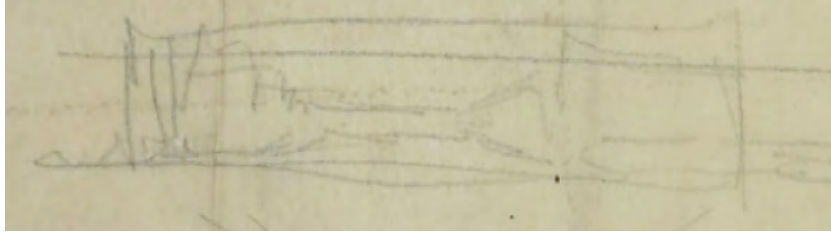


Fig. 91. Series of perspectival studies of groups of Domino frames, gradually transforming from a quadrangle to a street organizational scheme.
Sources: FLC 19141; FLC 19132; FLC 19224; FLC 19225; FLC 19226.

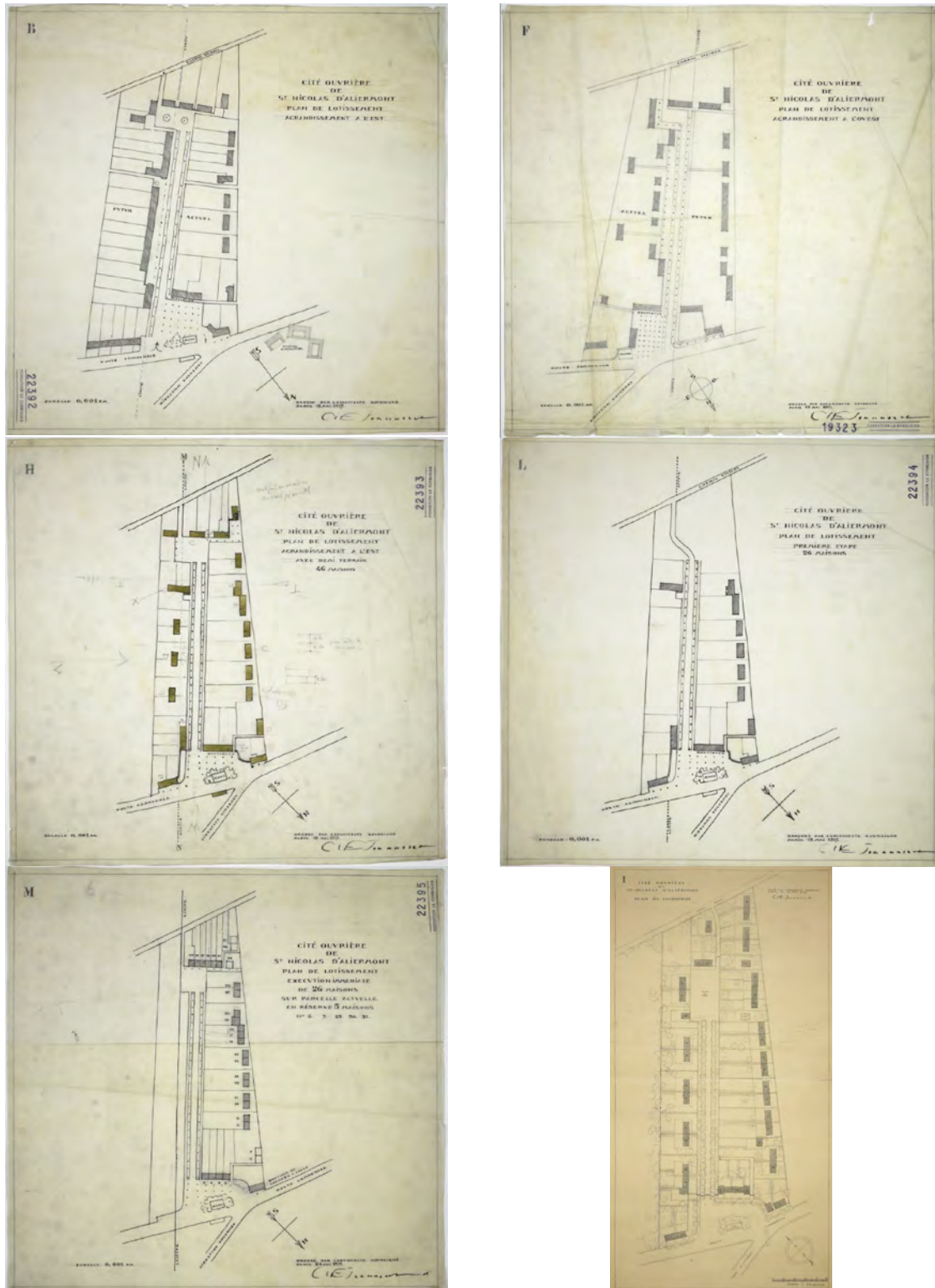


Fig. 92. Series of settlement design schemes for Le Corbusier, Cité Ouvrière de St Nicolas D'Alhiermont, 1917. Sources: FLC 22392 "Plan de Lotissement Agrandissement a L'Est - B", May 15, 1917; FLC 19323 "Plan de Lotissement Agrandissement a L'Ouest - F", May 19, 1917; FLC 22393 "Plan de Lotissement Agrandissement a L'Est Avec Demi Terrain 46 Maisons - H", May 19, 1917; FLC 22394 "Plan de Lotissement Première Etape 26 Maisons - L", May 19, 1917; FLC 22395 "Plan de Lotissement Execution Immédiate De 26 Maisons - M", May 24, 1917; FLC 22376 "Cité Ouvrière de St Nicolas D'Alhiermont Plan de Lotissement", June 20, 1917.

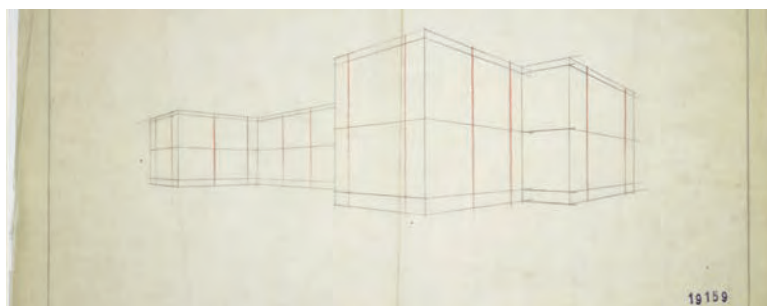
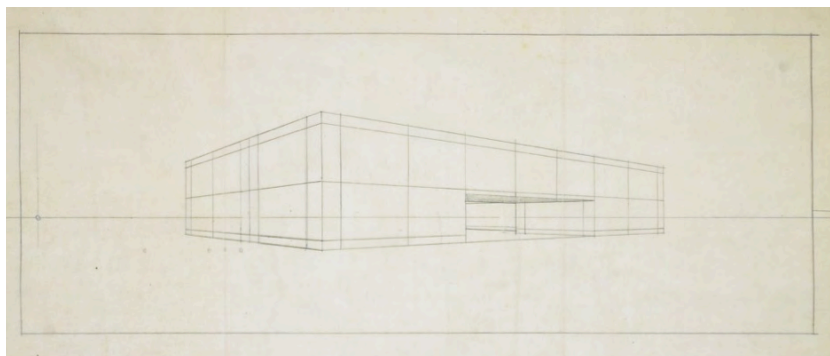


Fig. 93. Spread from “Maisons En Série” showing Maison Monol scheme, the “Maison Domino” and a Domino frame (top) and perspectival studies of a duplex grouping that informed the Maison Domino scheme (bottom).”

Source: Corbusier, Le. “Maisons En Série.” *L’Esprit Nouveau* 13 (1922): 1525-42; FLC 19159, 19214.

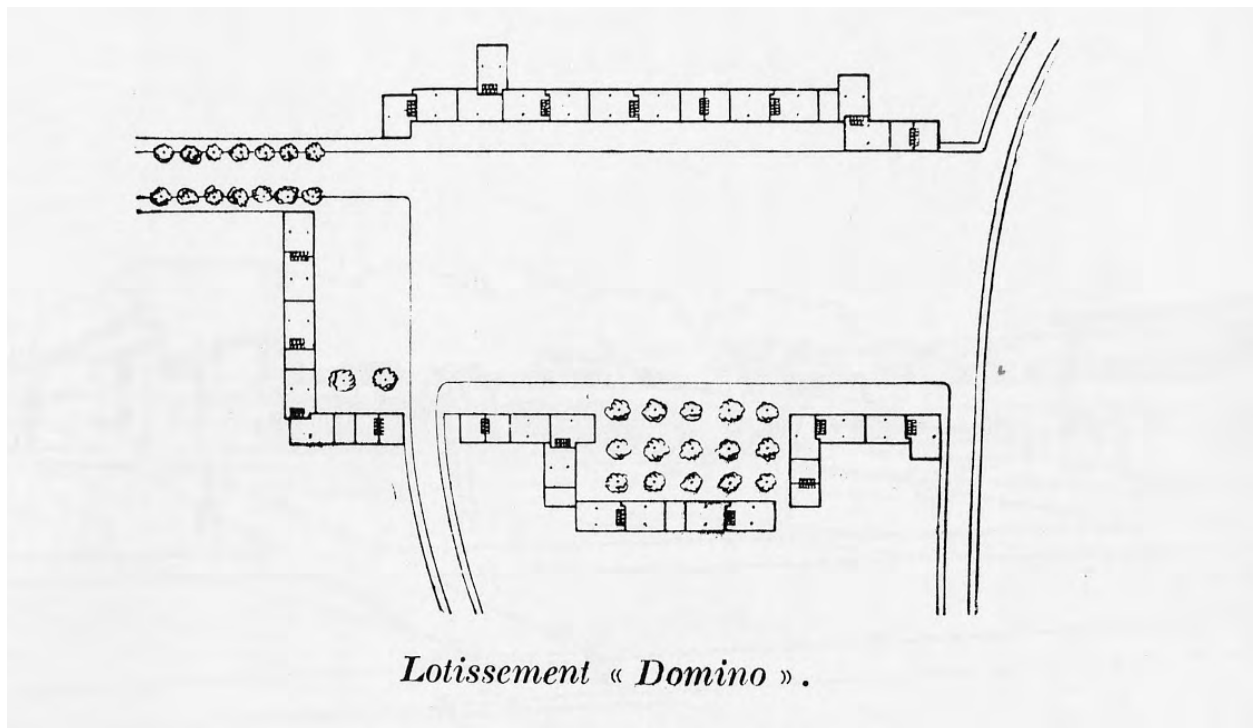


Fig. 94. Plate from "Maisons En Série" showing a Domino settlement.
 Source: Corbusier, Le. "Maisons En Série." *L'Esprit Nouveau* 13 (1922): 1525-42.

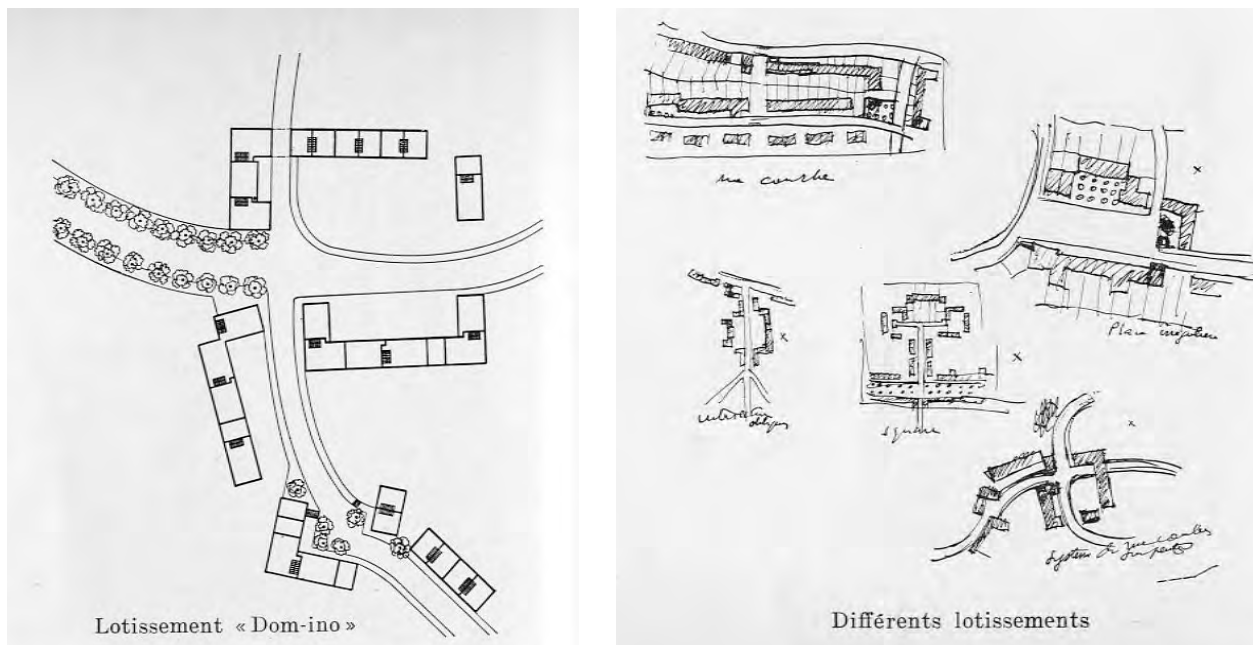


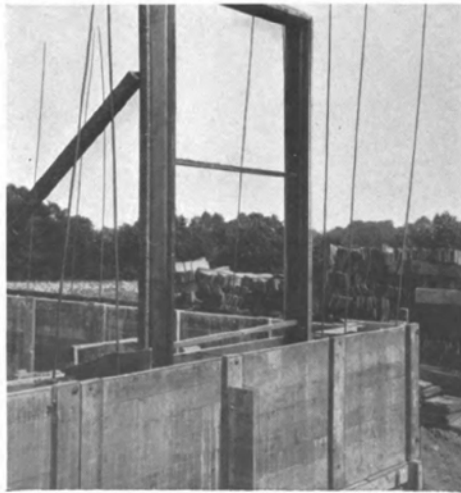
Fig. 95. Plates from *Oeuvre Complete* showing another Domino Settlement, in detail, and sketches of "different settlements" (bottom). Compare to Figs. 43, 45 and 48.
 Source: *Oeuvre Complete*, 1936.



Workers' College, Sewaren, N. J. Starr Foundation Homes Co. *Greene A. Barber, Architect, N. Y.*
 A fireproof, sanitary, and indestructible house, built throughout of huge, precast concrete slabs, and intended to solve the problem of better living conditions for working classes at minimum cost.



Residence of G. L. Calkins, Oklawaha, Fla. *Harry E. Thross, Architect*
 House constructed with Van Gulder hollow concrete walls. Mixture and plaster applied directly to walls.



Method of securing window frames during wall construction.
 [77]



Pouring concrete into a column form.
 [78]

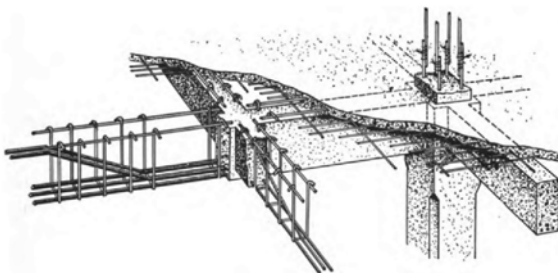


Fig. 38.—Example of fabricated reinforcement.

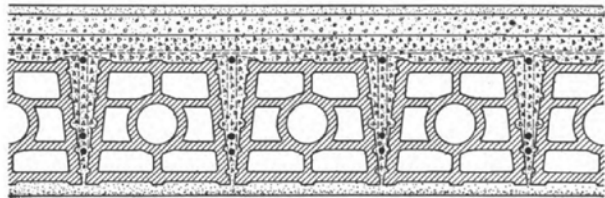


Fig. 36.—Arrangement of concrete and hollow splayed tile.

Fig. 96. Plates from *The Concrete House and Its Construction*, showing the Sewaren House, the Calkins Residence, "photographs of the use of mass produced windows as part of the form work, the use of concrete forms as scaffolding, as well as drawings of floor construction using "fabricated reinforcement" and the lost tile method. Compare with Figs. 93, 97, 100 and 101.

Source: Sloan, Maurice M. *The Concrete House and Its Construction*. Philadelphia: The Association of American Portland Cement Manufacturers, 1912.

contraintes imposées par des nécessités impérieuses entraînant de grands efforts et des dépenses fâcheuses. Or, aujourd'hui, chez les architectes, les arceaux et les voûtes sont devenus les éléments les plus spontanés sans plus aucun souvenir de leur évolution, — sélection et économie.

Le ciment armé, à côté de bien d'autres conséquences esthétiques, apporte cette donnée fondamentale de la droite qui est



une donnée digne de ce temps et digne de plaire aux gens de notre temps. Or, c'est là une innovation qui déplait encore à certains architectes ; le nationalisme même s'en mêle et certains esprits ont décrété que la ligne droite était « boche » (voir le Parthénon, les temples égyptiens et les palais de Babylone). La ligne droite, c'est l'un des droits de l'homme. Dans sa villa, Le Corbusier a adopté un plan constructif extrêmement hardi, puisque toute sa maison ne repose que sur quatre petits poteaux intérieurs de 20 centimètres. Les murs autrefois, épais et encombrants, sont remplacés par des membrures isolantes avec matelas d'air, minces comme une feuille. On construit les grands frigorifiques avec des cloisons

Fig. 97. Page from "Une villa de Le Corbusier" showing Le Corbusier's first use of the reinforced concrete frame and lost tile process for the construction of the Villa Schwob, essentially the first published image of the Domino frame, in use.

Source: (Ozenfant), Julien Caron. "Une Villa De Le Corbusier." *L'Esprit Nouveau* 6 (1921): 679.

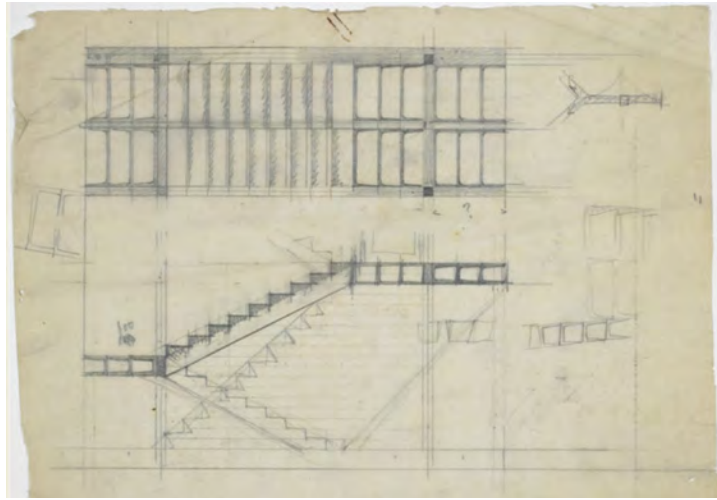


Fig. 99. Le Corbusier. Plan and section studies of stair constructed with lost tile process assembly (top) and interior elevation studies of the relationship of type furniture to the Domino frame (bottom).
Sources: FLC 19138; FLC 19151.

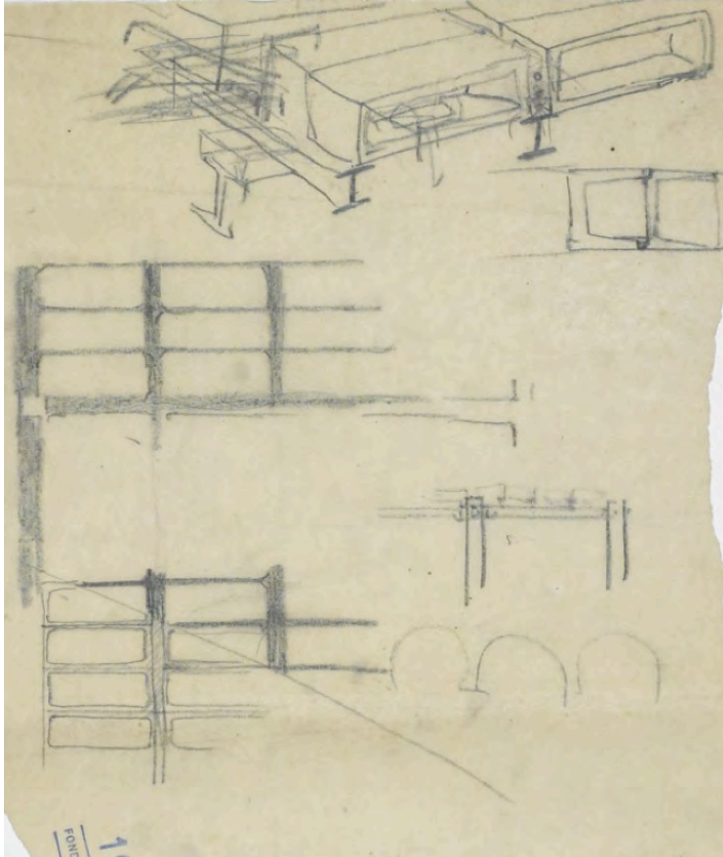


Fig. 100. Le Corbusier. Studies of lost tile assembly construction, including a study for reusable steel centering formwork.
Source: FLC 19136.

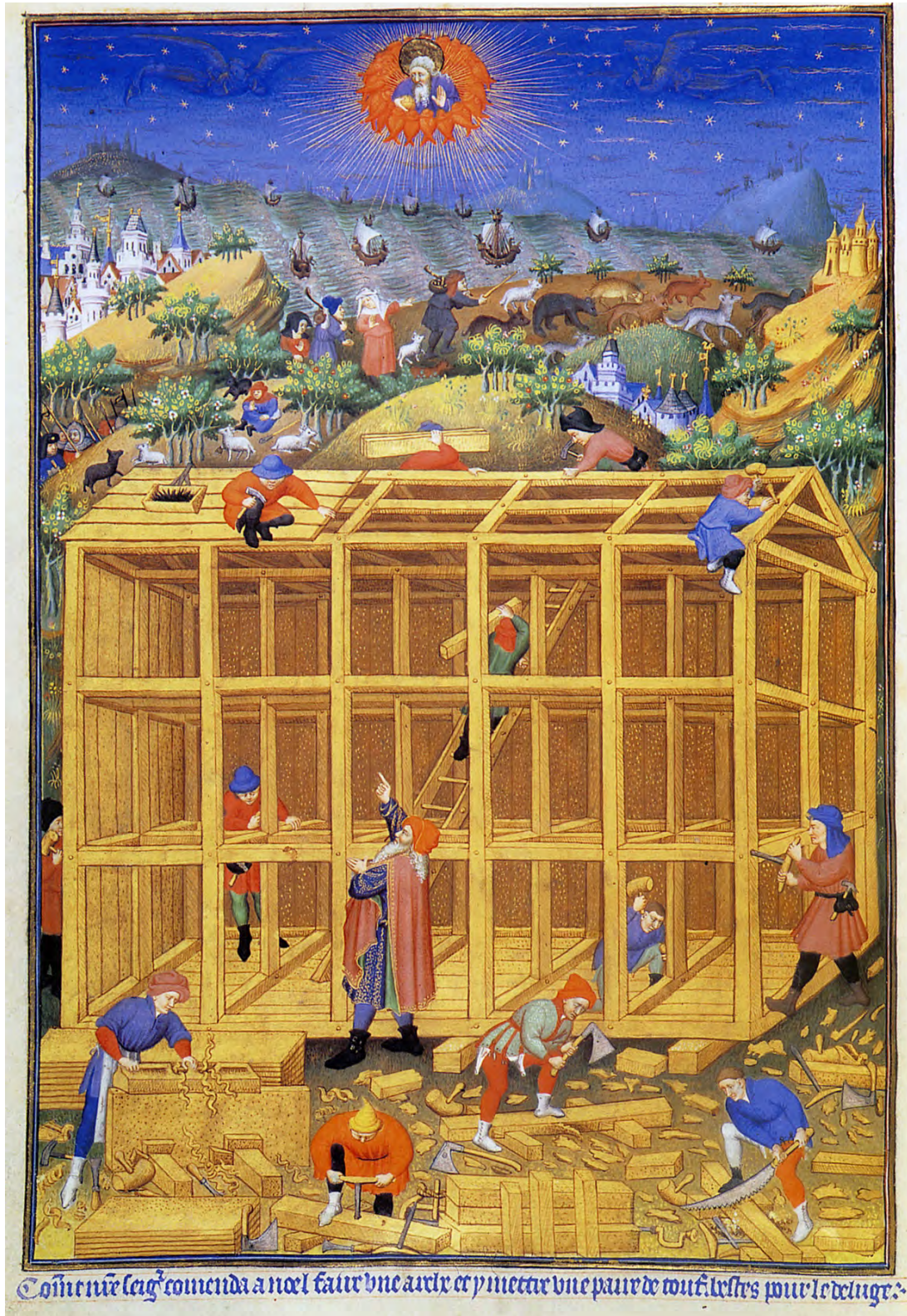


Fig. 101. Plate from The Bedford Hours, "Miniature of the building of Noah's Ark", showing the function of a heavy timber structure as a physical and organizational frame for more skilled construction work, managed by a master builder, in the foreground.

Source: BL Add MS 18850, f. 15v (the "Bedford Hours"). Held and digitized by the British Library.

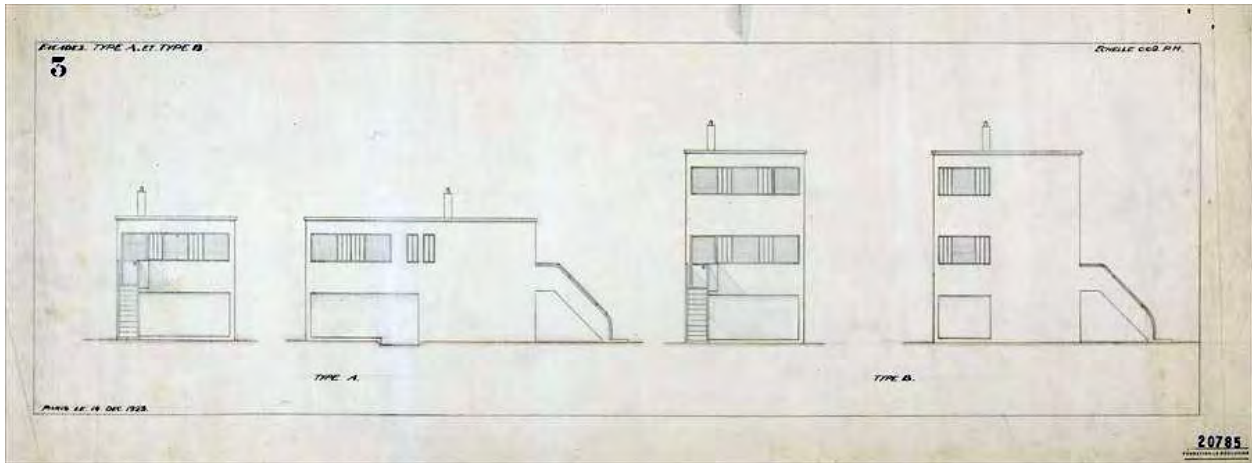


Fig. 102. Le Corbusier. Front and side elevations of Lege Type A and B, December 24, 1923.
Source: FLC 20785

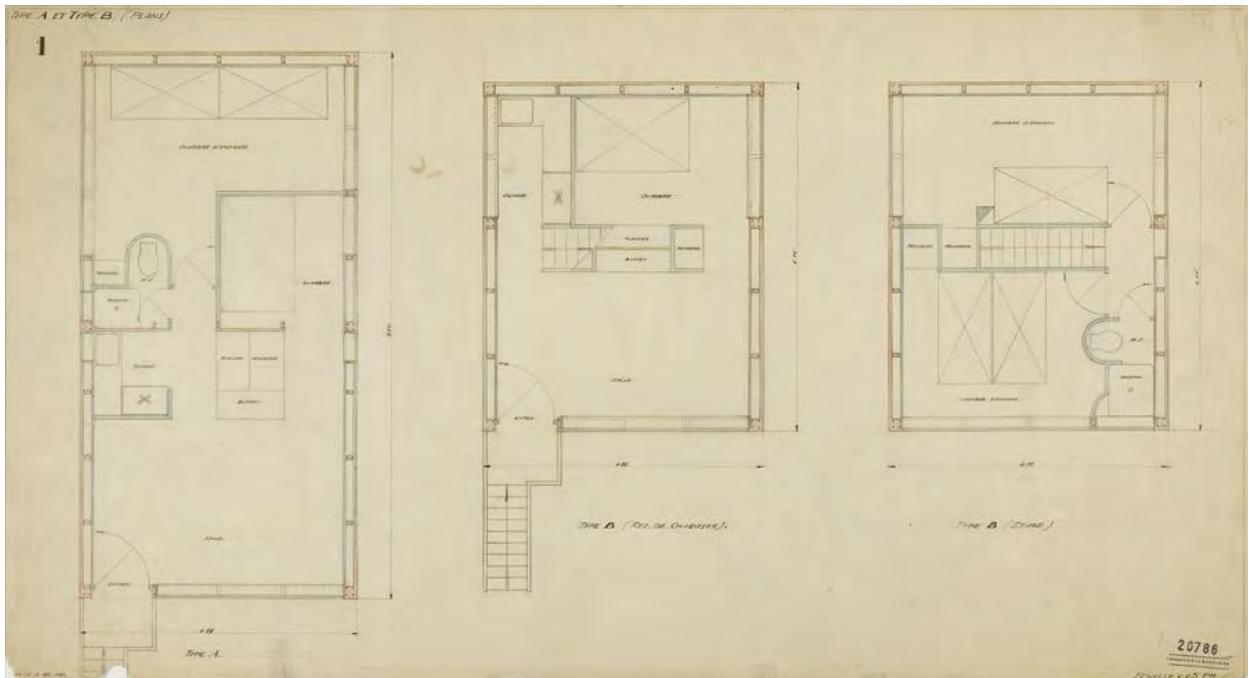
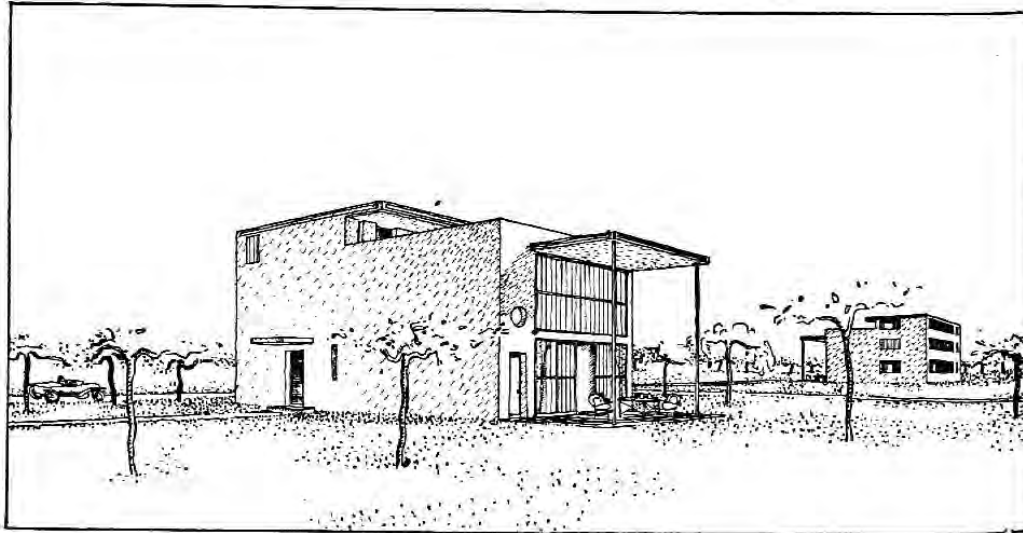
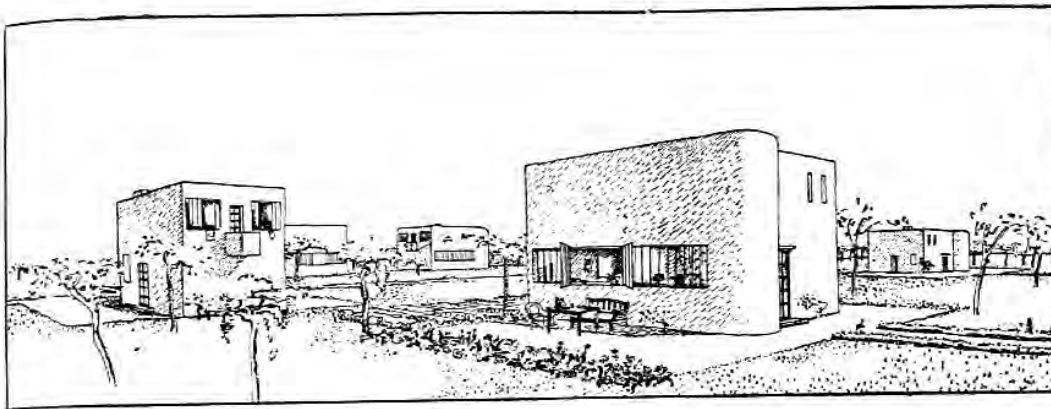


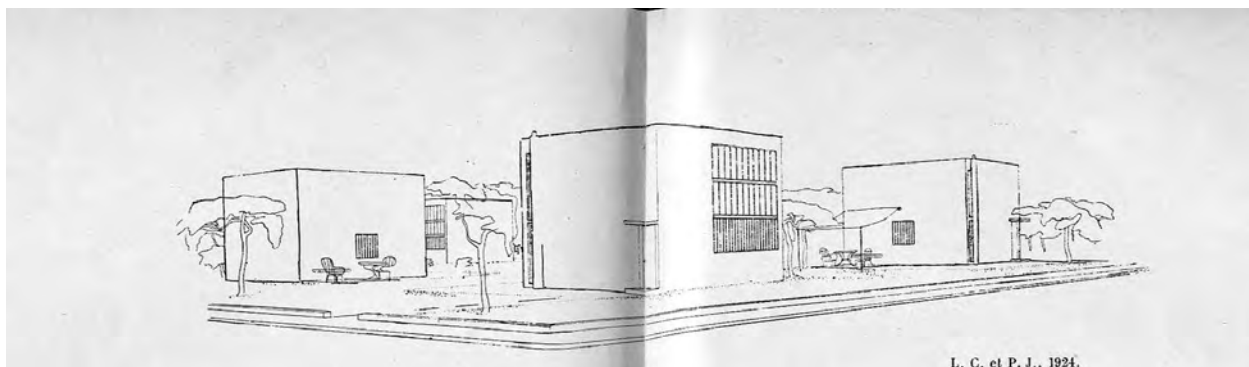
Fig. 103. Le Corbusier. Plan studies of Type A (left) and Type B (center and right), December 1923.
Source: FLC 20786



L. C., 1922. Villa en série, 72 m². Ossature de ciment, ciment-gun. Une grande salle de 9 x 5; une cuisine, une chambre de bonne; une chambre à coucher, salle de bains, boudoir; deux chambres à coucher, un solarium.



L. C., 1922. Maison ouvrière en série. Un lotissement bien fait, la même maison peut se présenter sous divers angles. Quatre poteaux de ciment; les murs en « ciment-gun ». Esthétique ? L'architecture est chose de plastique, non de romantisme.



L. C. et P. J., 1924.

Fig. 104. Plates from *Toward An Architecture* showing Le Corbusier's Villa in series, 1922 (top), Villas for workers in a series, 1922 (middle), Villas for artisans, 1924 (bottom).
Source: Le Corbusier. *Vers Une Architecture: Nouvelle Éd. Revue Et Augmentée*. 2 ed. Paris: G. Crès et Cie, 1924.



Fig. 105. Le Corbusier. Perspectival study of a series of Lege Type B's, undated.
Source: FLC 20784.

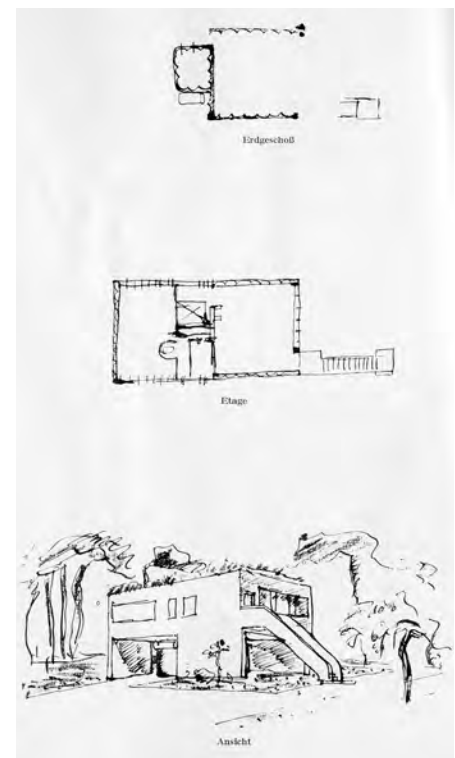


Fig. 106. Plates from Oeuvre Complete (1929) showing the Maison Du Tonkin.
Source: Le Corbusier, P. Jeanneret. *Ihr Gesamtes Werk Von 1910-1929*. Zurich: Verlag Dr. H.Girsberger & CIE., 1930. 68.

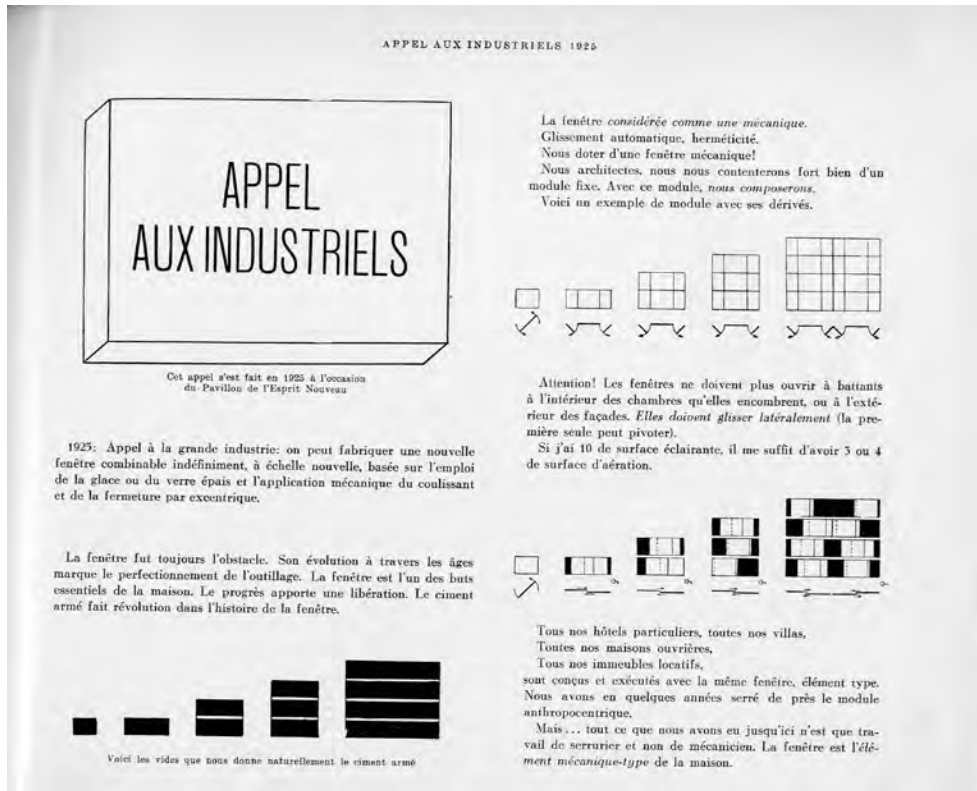


Fig. 107. Page from Oeuvre Complete showing Le Corbusier's "Appeal to the Industrialists", 1925.
Source: Oeuvre Complete, 1936. 77.



Fig. 108. Le Corbusier. Settlement plan of Pessac and sketches of cement-gun construction, July 25, 1924.
Source: FLC 19853.

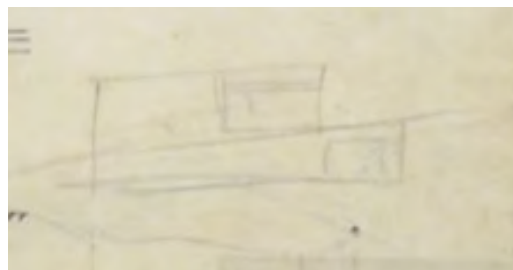
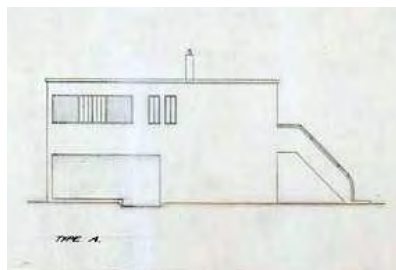
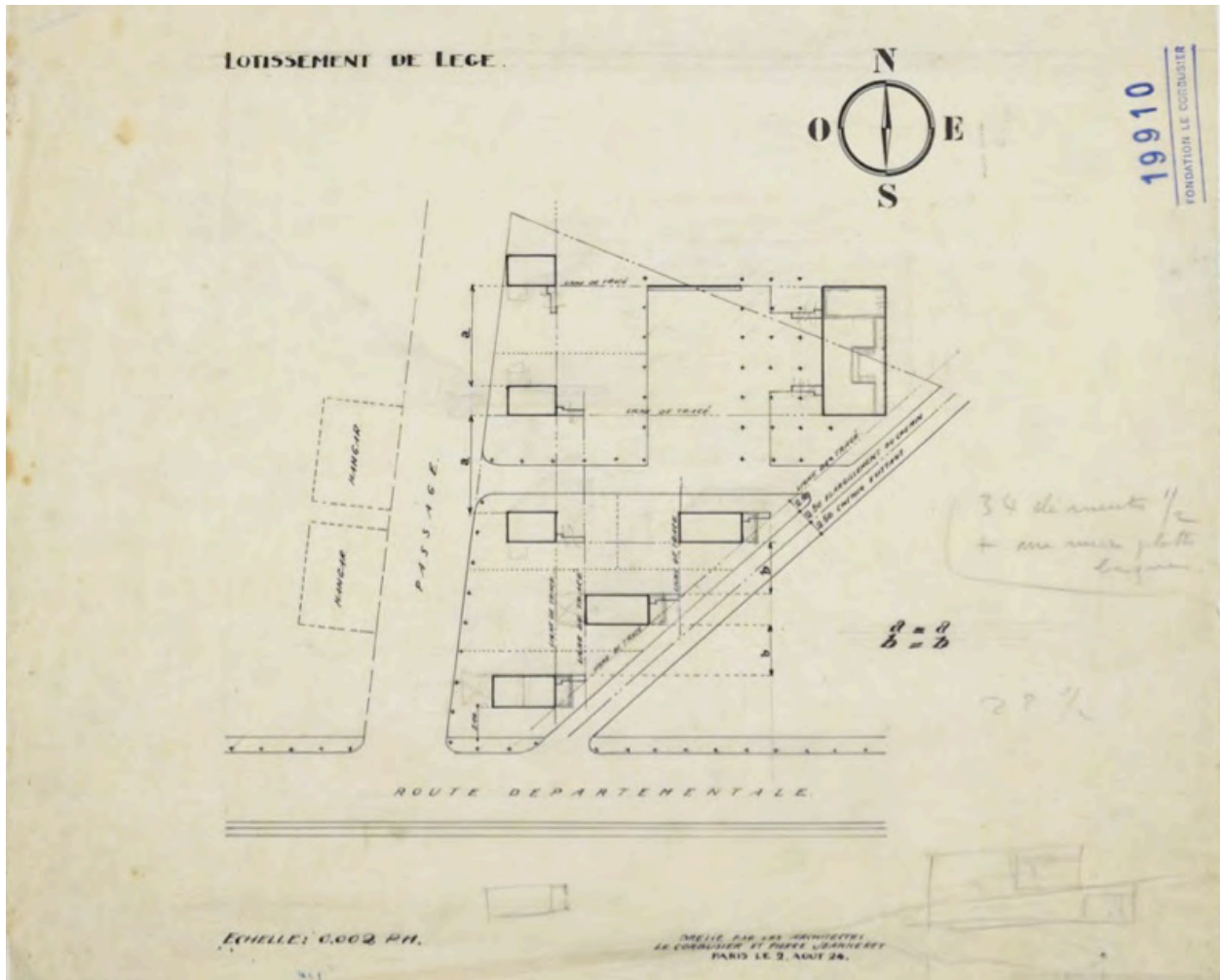


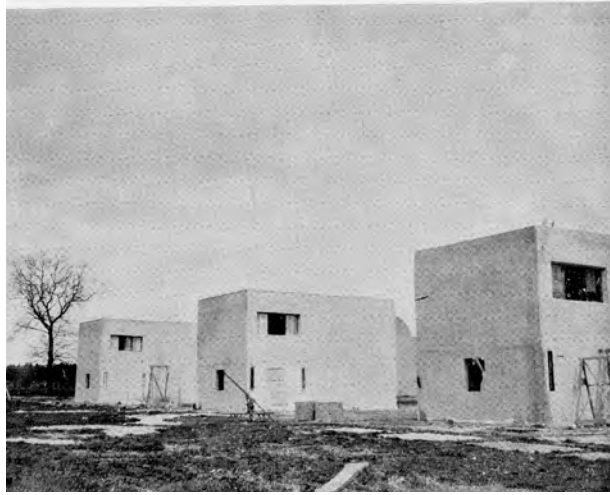
Fig. 109. Le Corbusier. Settlement plan of Lege, August 2, 1914, with modifications, in pencil made afterwards. Source: FLC 19910.



Fig. 110. Photographic study of the experience of the houses in series at Lege, 2012.
Source: Author.



Fig. 111. Aerial photograph of Lege showing adjustment made to the units due to the incorrect site survey.
Source: Google Earth.



Die Siedlung Lège

Fig. 112. Page from *Oeuvre Complete* (1929) showing Lege.
Source: Le Corbusier, P. Jeanneret. *Ihr Gesamtes Werk Von 1910-1929*. Zurich: Verlag Dr. H.Girsberger & Cie. , 1930. 69.



Fig. 113. Photograph of Lege Type A showing “cubes of air”, 2012.
Source: Author.

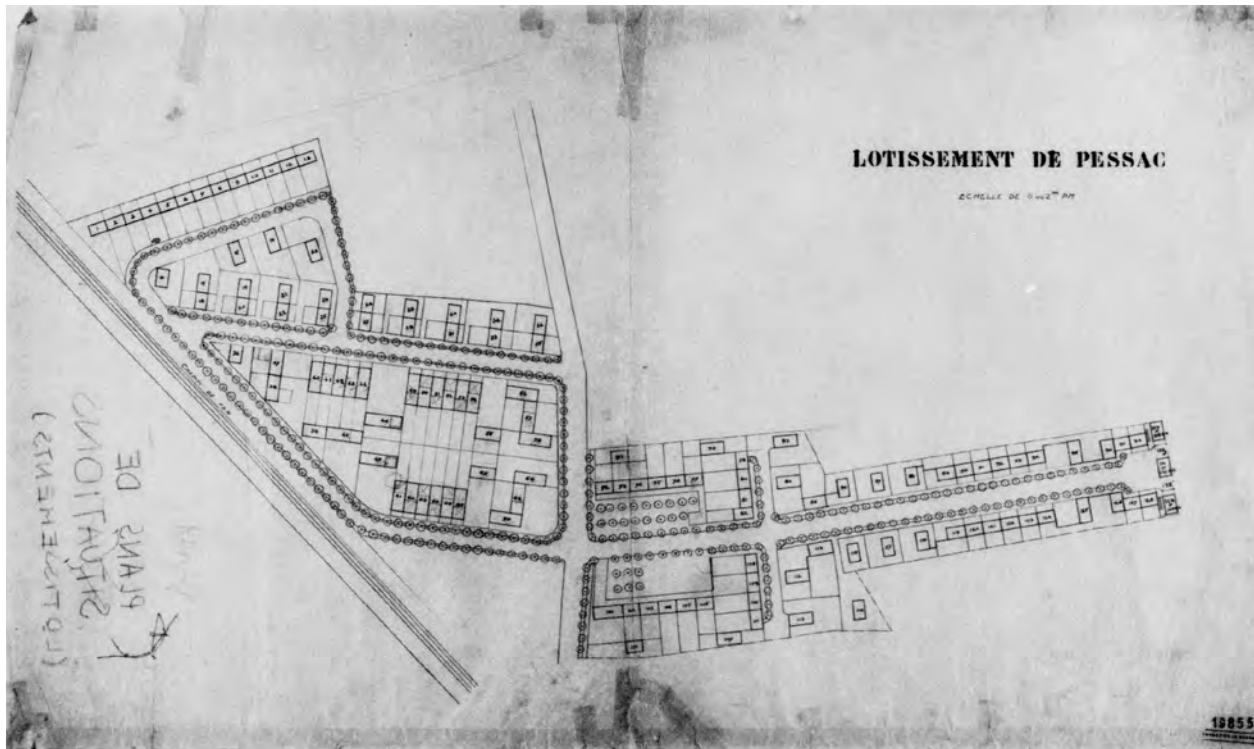


Abb. 91. Der ausgeführte Teil der SIEDLUNG CORBUSIERS IN PESSAC 1925/26
 Befreiung von der starren Gebundenheit der Siedlungsgrundrisse. Die freie, lockere Austeilung entspricht dem Charakter des heutigen Hauses, der so geformt ist, daß Nähe nicht zugleich Bedrängnis bedeutet, denn Einzelheit und Gesamtheit sind geöffnet.

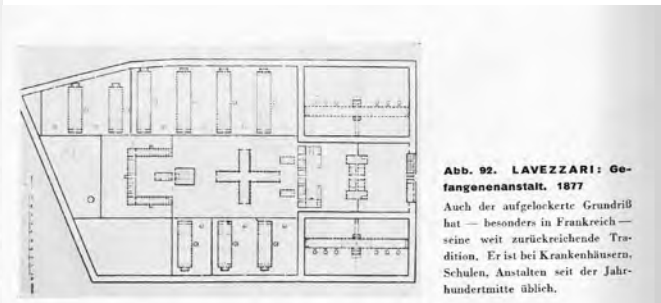


Abb. 92. LAVEZZARI: Gefangenenanstalt, 1877
 Auch der aufgelockerte Grundriß hat — besonders in Frankreich — seine weit zurückreichende Tradition. Er ist bei Krankenhäusern, Schulen, Anstalten seit der Jahrhundertmitte üblich.

Fig. 114. Le Corbusier: "Pessac Settlement", 1924 (October?) and plates from Giedion, *Bauen in Frankreich, Eisen, Eisenbeton*, comparing the 1924 Pessac Settlement scheme to a hospital.
 Sources: FLC 19855; Giedion, Sigfried. *Bauen in Frankreich, Eisen, Eisenbeton*. Berlin: Klinkhardt and Biermann Verlag, 1928. 88.

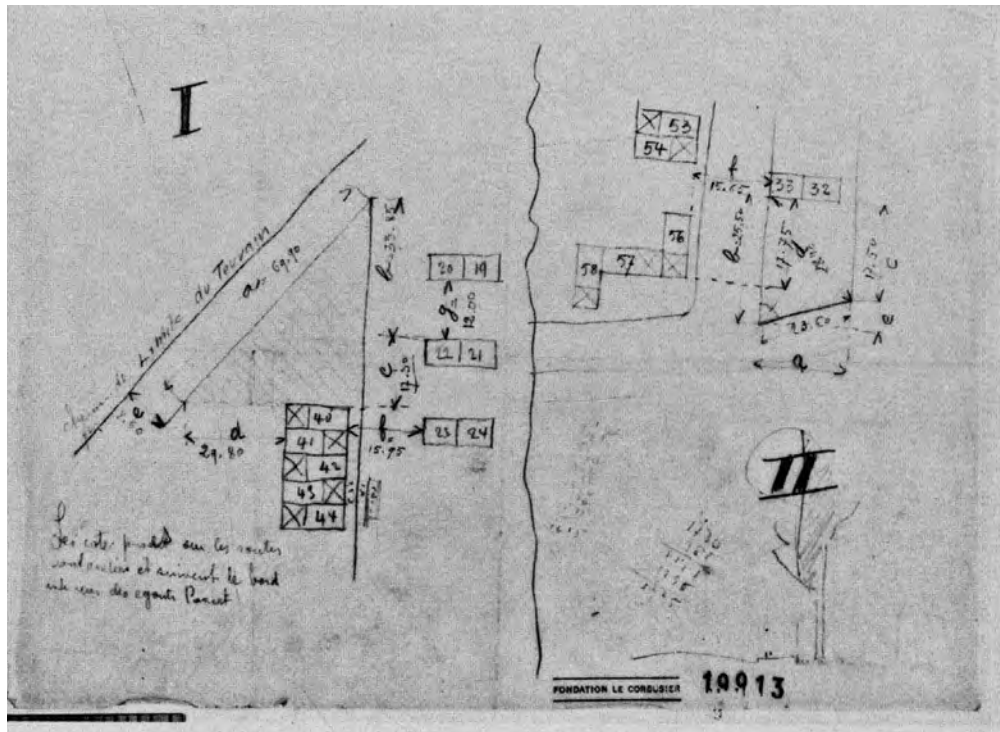


Fig. 115. Le Corbusier. Studies of proportional and dimensional relationships of Domino frames as Pessac, 1924.

Source: FLC 19913

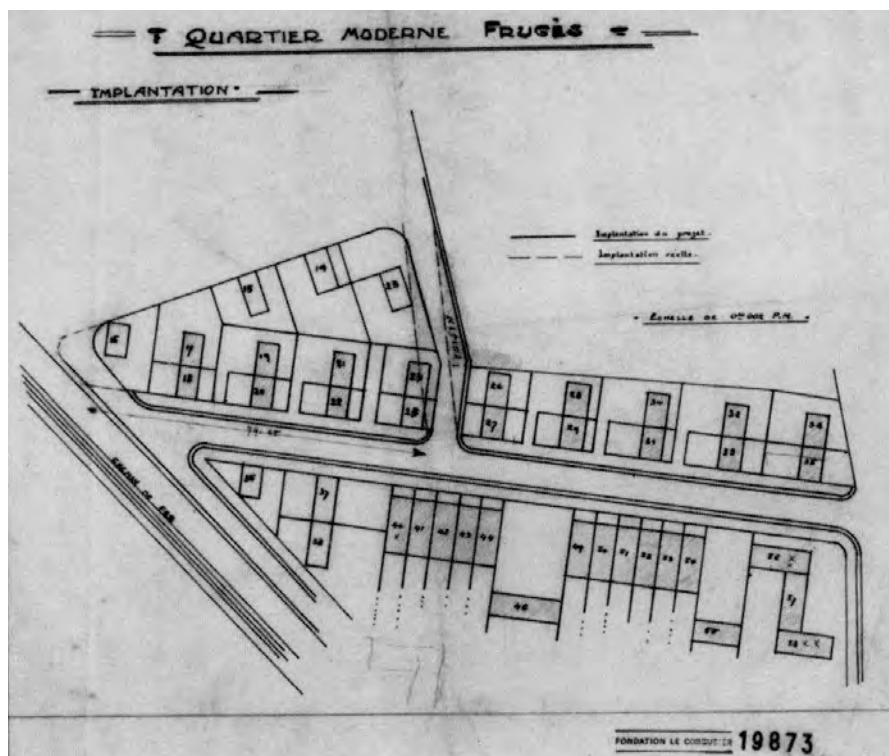


Fig. 116. Le Corbusier. "Quartier Moderne Fruges – Implantation" showing the error of Poncet's survey and the needed adjustments to settlements scheme, 1924.

Source: FLC 19873

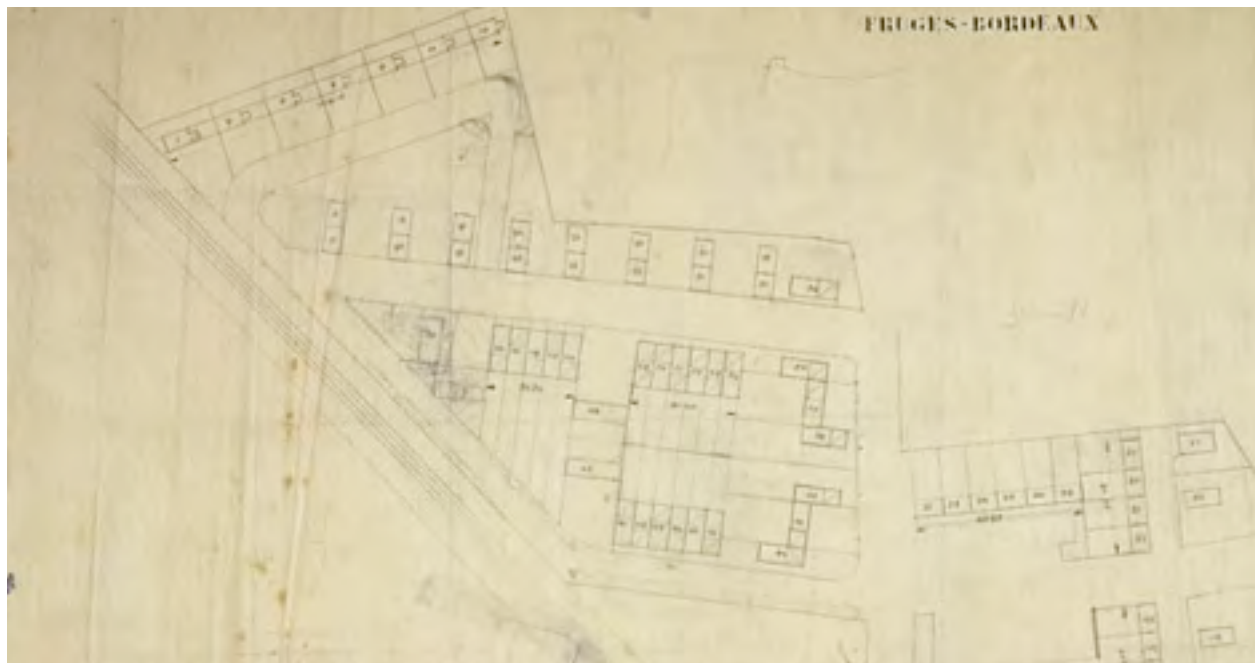
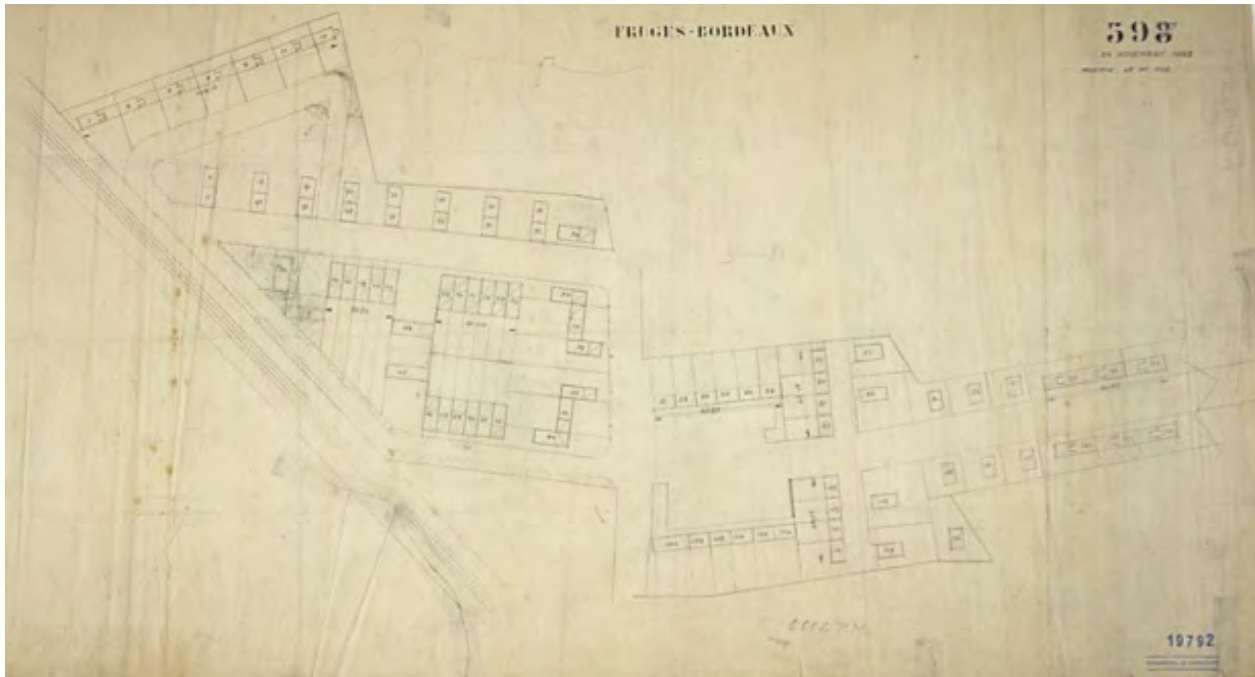
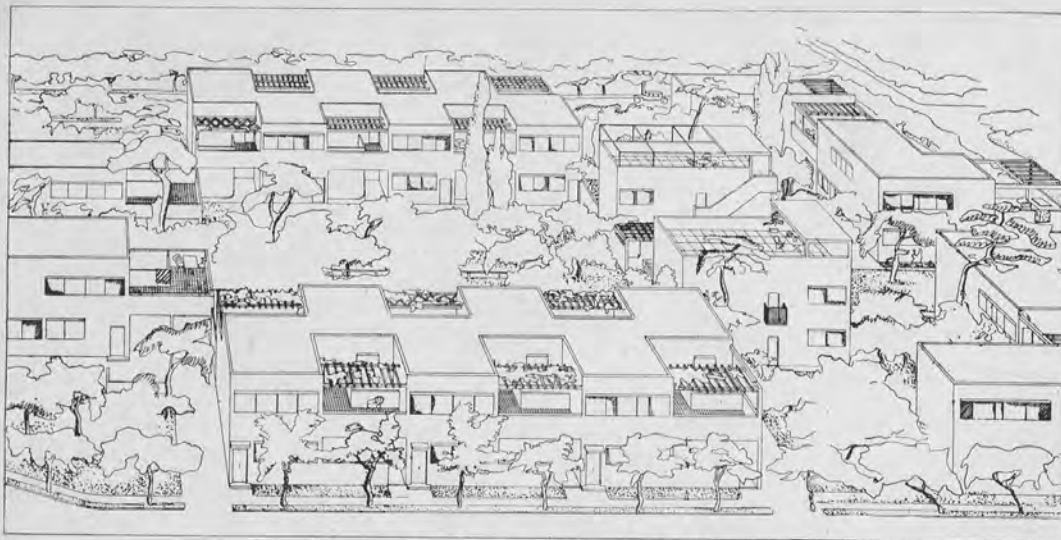
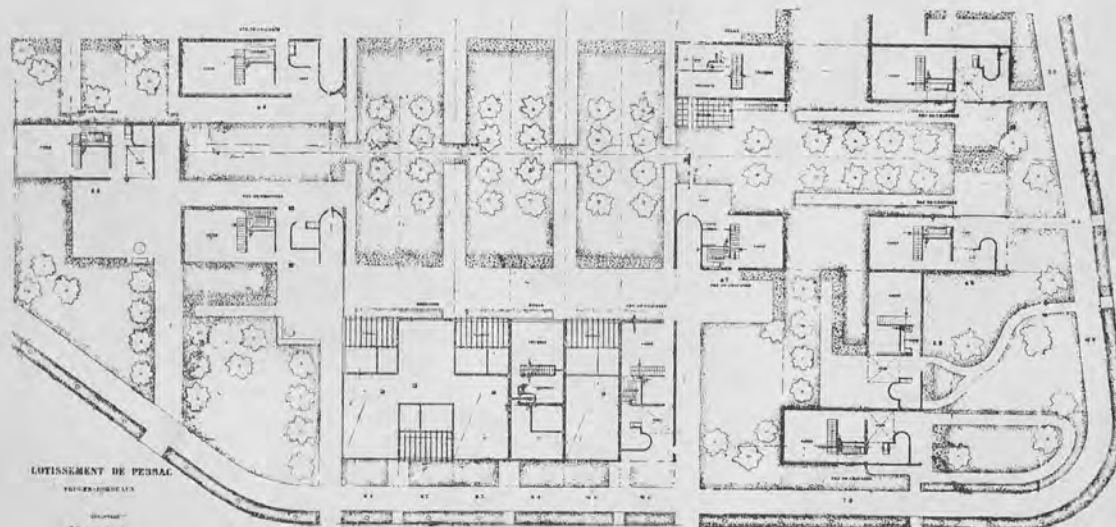


Fig. 117. Le Corbusier. "Fruges-Bordeaux", Pessac settlement scheme, November 24, 1924.
Source: FLC 19792



1924, Bordeaux-Pessac. « Quartiers Modernes Frugés ».
 Fragment d'un grand lotissement construit au canon à ciment. Un type d'élément a été minutieusement fixé, et il se multiplie avec les
 combinaisons les plus variées. C'est une véritable industrialisation du chantier.



LOTISSEMENT DE PESSAC
 PESSAC (GIRONDE)
 Bordeaux-Pessac.
 15 La première édition de ce livre a vivement touché un grand industriel de Bordeaux. Il fut décidé de faire table rase des usages et des habitudes. Une haute
 conception des choses de l'industrie et des destinées de l'architecture incitèrent cet industriel à prendre les initiatives les plus courageuses. Pour la
 première fois peut-être, en France, grâce à lui, le problème actuel de l'architecture se résoud dans un esprit conforme à l'époque. Économie, sociologie,
 esthétique : c'est une réalisation neuve avec des moyens neufs.

Fig. 118. Spread from *Toward an Architecture* showing birds-eye-view perspective (top) and detailed plan (bottom) of part of the Pessac settlement scheme, 1924.
 Source: Corbusier, Le. *Vers Une Architecture: Nouv. Éd. Rev. Et Augm.* 3 ed. Paris: G. Crès et cie., 1928. (the top drawing was already included in the 1924 edition).

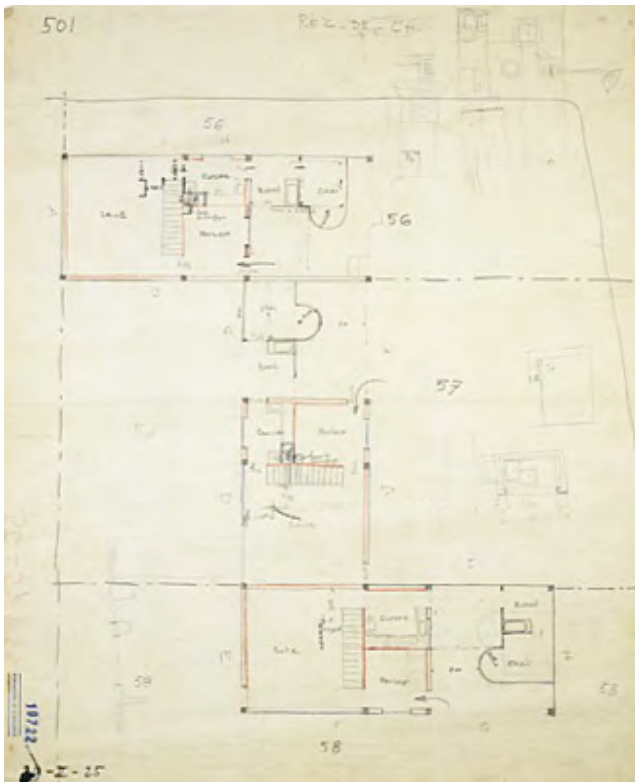
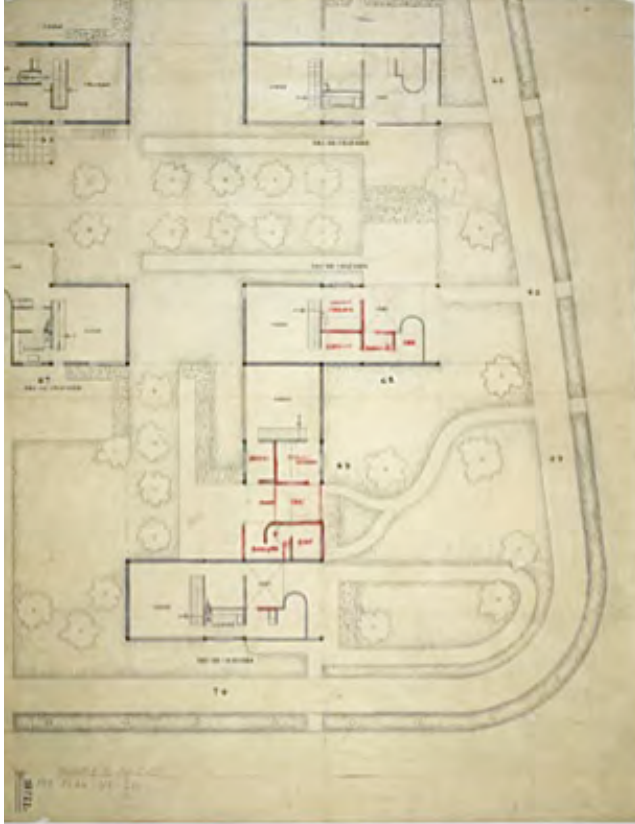


Fig. 119. Le Corbusier. Planometric studies of the triplex groupings in Sector C in relation to other units (top) and internally (bottom), February 29, 1925.

Sources: FLC 19722C; FLC 19722A

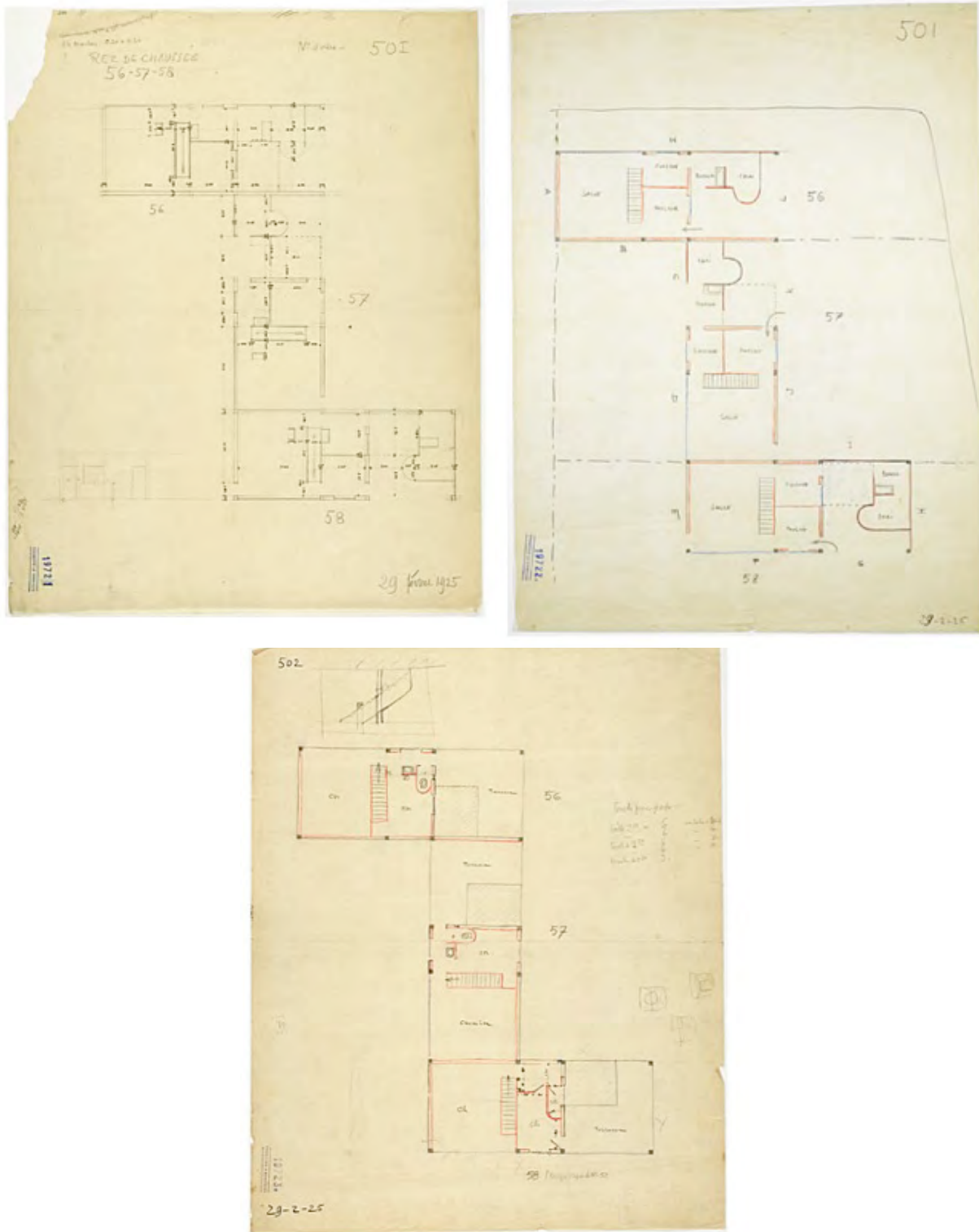


Fig. 120. Le Corbusier. Planometric studies of a triplex grouping in Sector C, fixing the dimensions of key elements (top left) and examining the volumetric qualities of the wrapped domestic equipment (top right) of the ground floor and examining the same issues on the upper floor (bottom).
Sources: FLC 19721B; FLC 19722B; 19723B

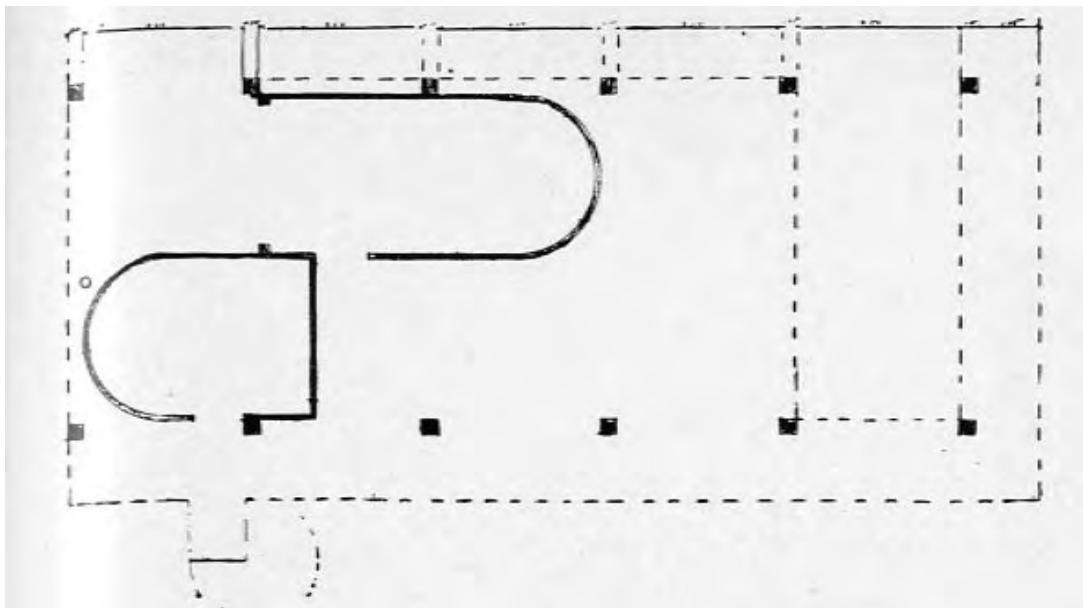
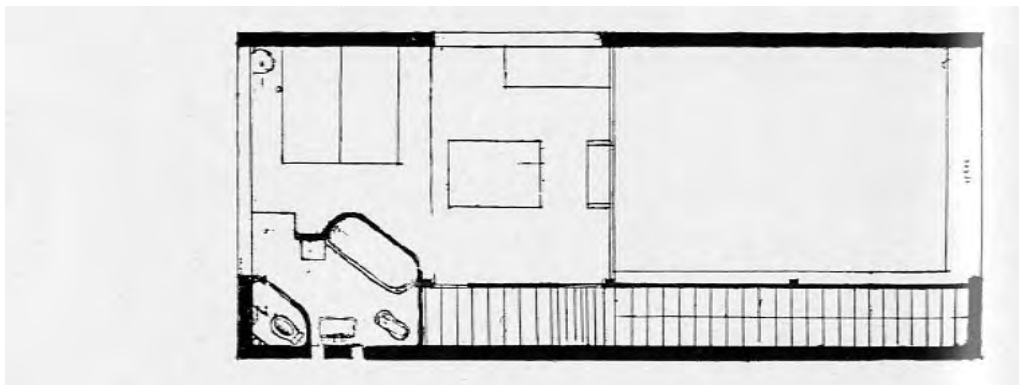
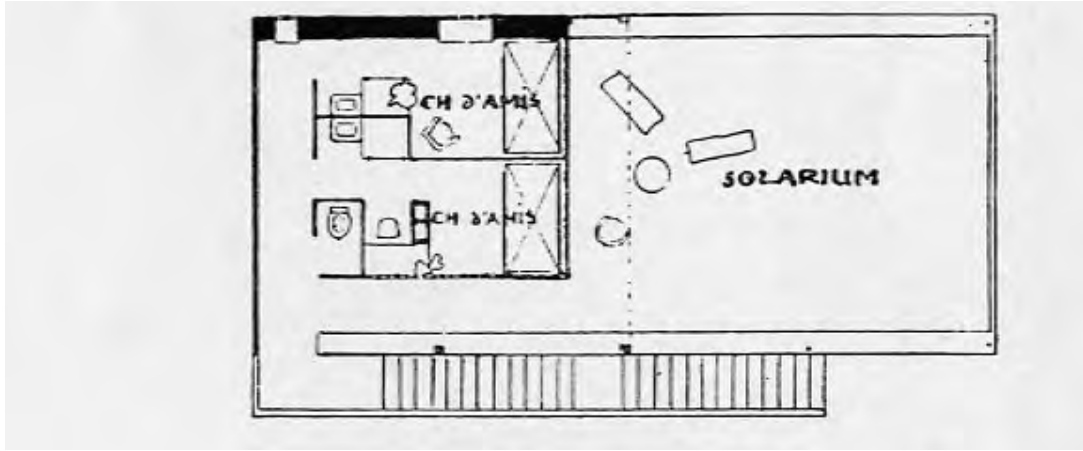


Fig. 121. Plates from *Oeuvre Complete* showing the evolution of Le Corbusier's free planning techniques through the floor plan of Maison Citrohan (1920) (top), prior to Bordeaux, Maison Citrohan (1924?) (middle), during Bordeaux, and the Stuttgart Villa (1926) (top), after Bordeaux.
 Source: *Oeuvre Complete*, 1936. 31, 47.

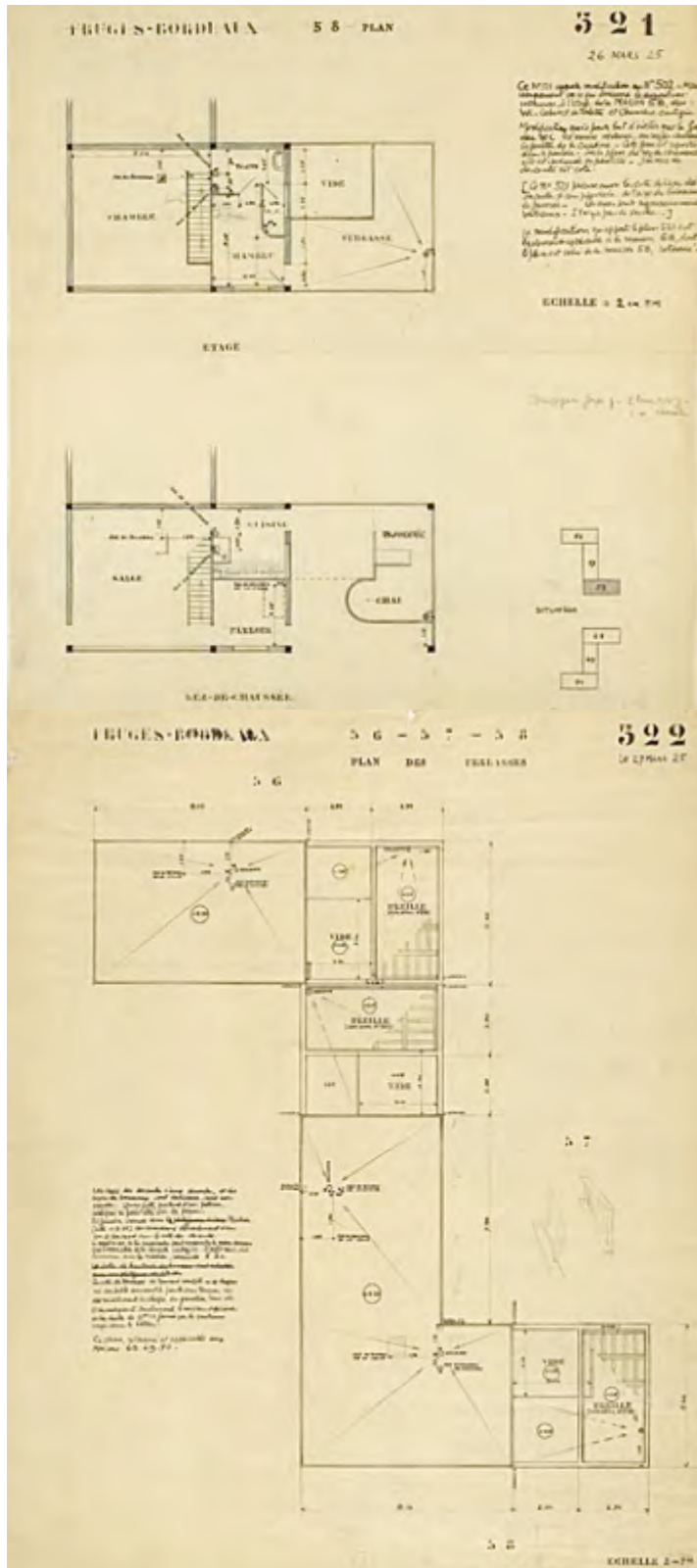


Fig. 122. Le Corbusier. Plan of one of the triplex units, on parcel 58 (top) and plan of entire triplex group on parcels 56, 57 and 58 (bottom), March 26 and 27, 1925.
Sources: FLC 19739; FLC 19740.

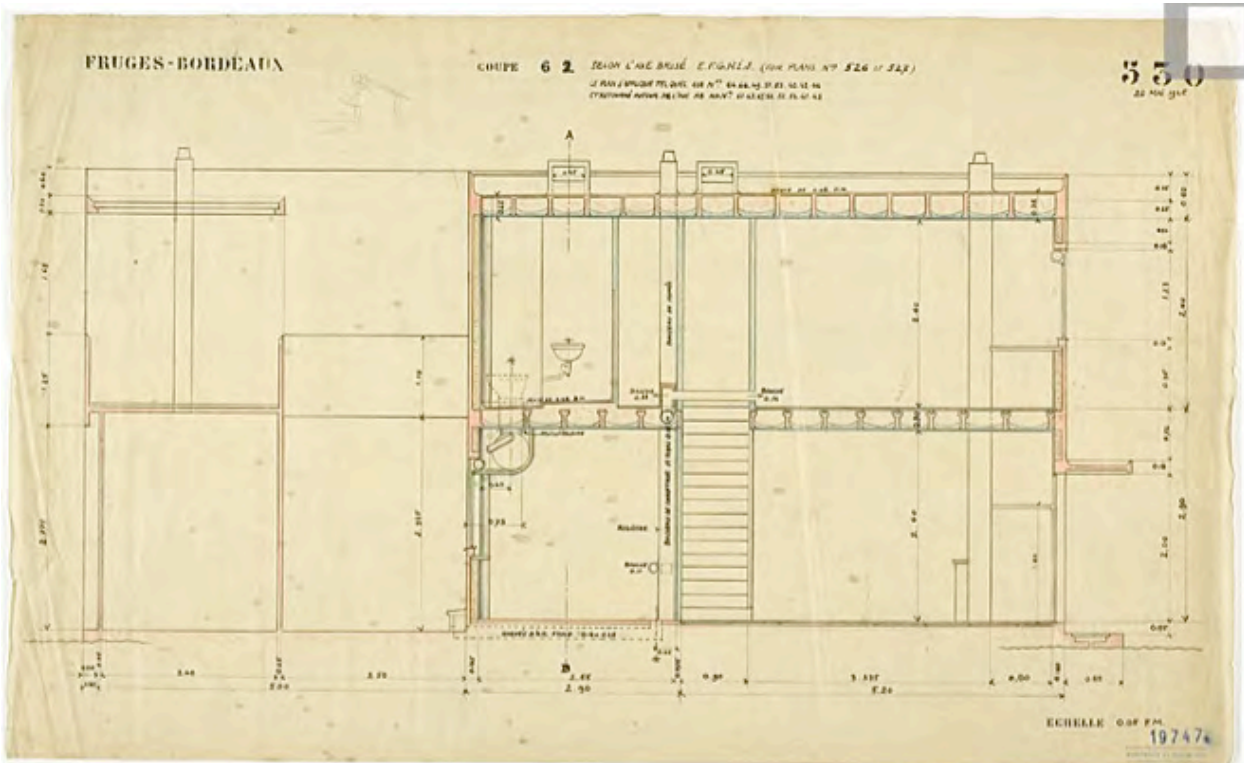
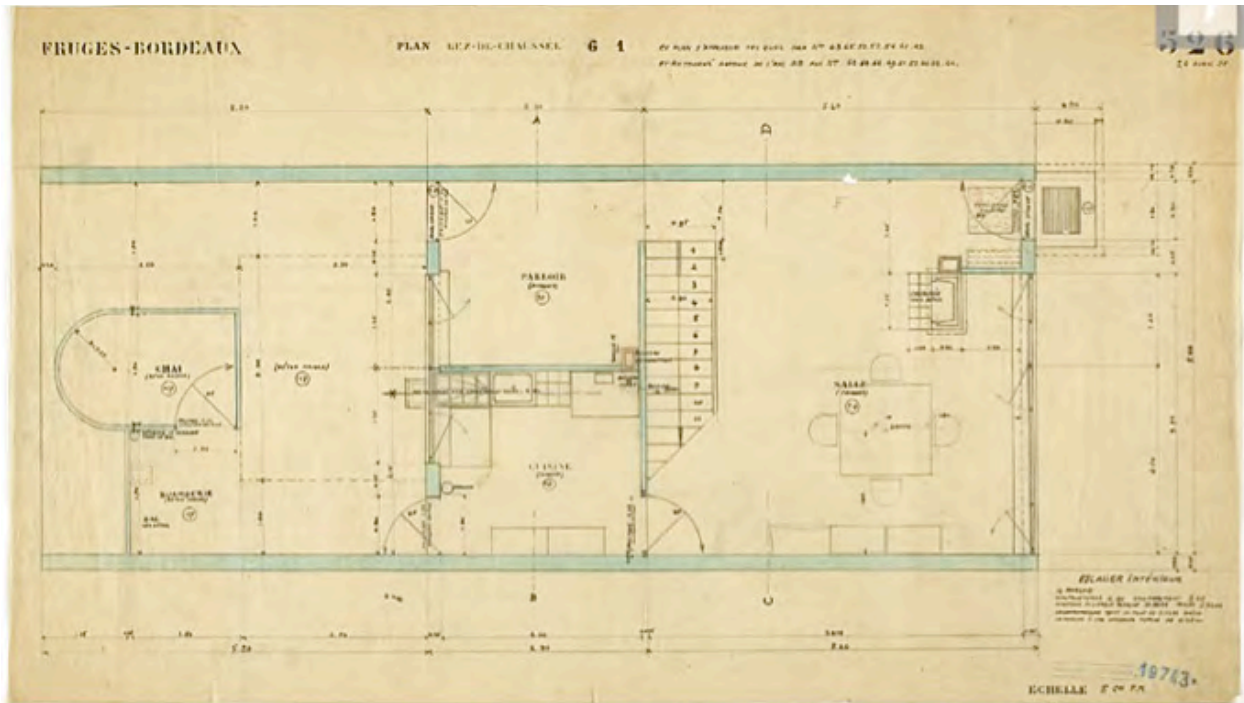


Fig. 123. Le Corbusier. Plan (top) and section (bottom) of one of the units grouped in rows, showing move away from cement gun construction, May 20, 1925. Compare with Fig. 119 and 122 to see repetition and variation of Lege Type A.
 Source: FLC 19743; FLC 19747.

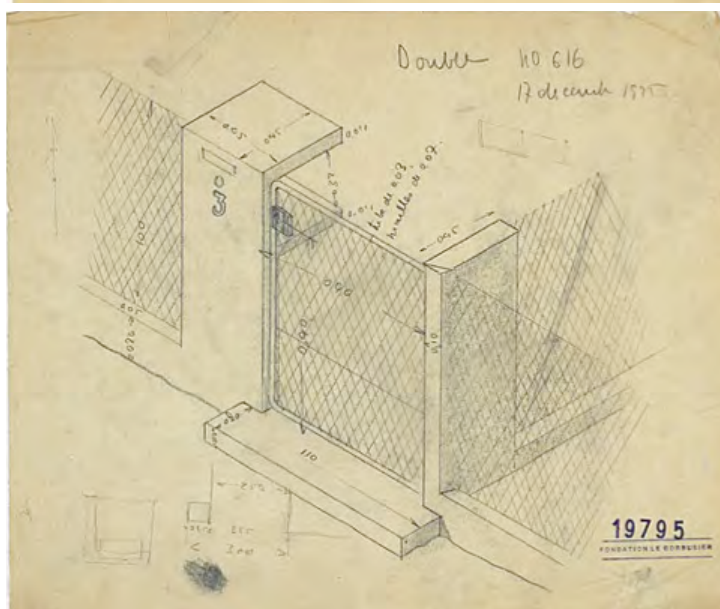
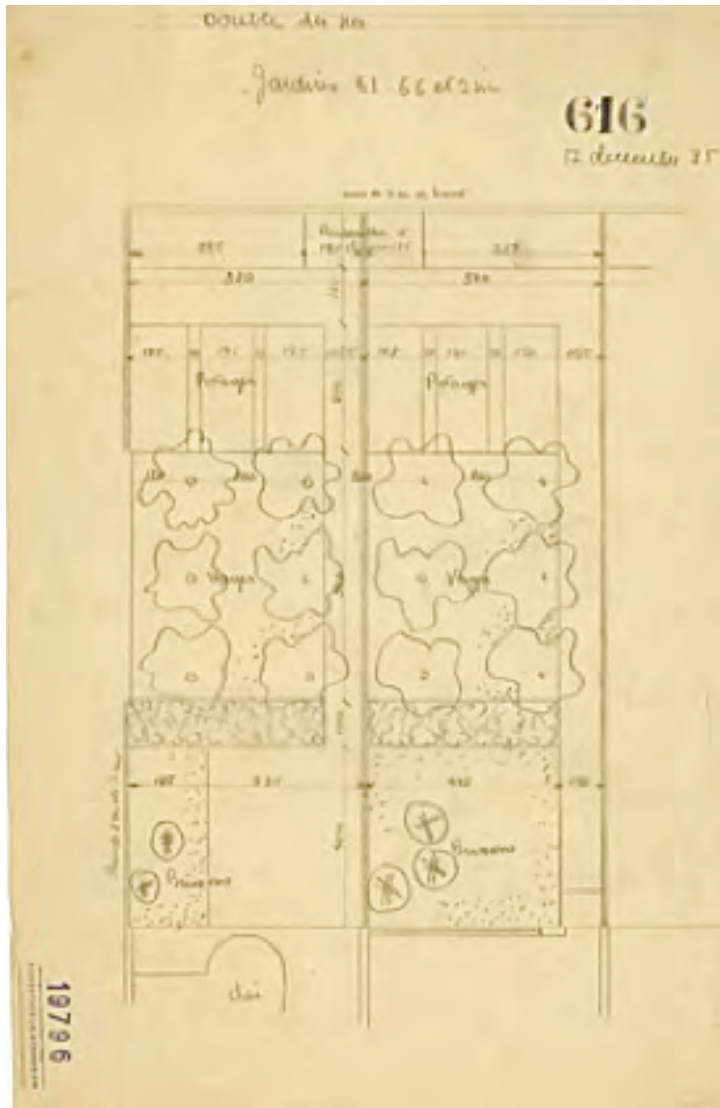


Fig. 124. Le Corbusier. Plan of allotment gardens attached to row-house units in groups (shown in Fig. 123) (top) and detail of garden gate for allotment gardens (bottom), December 17, 1925.

Sources: FLC 19796; FLC 19795.

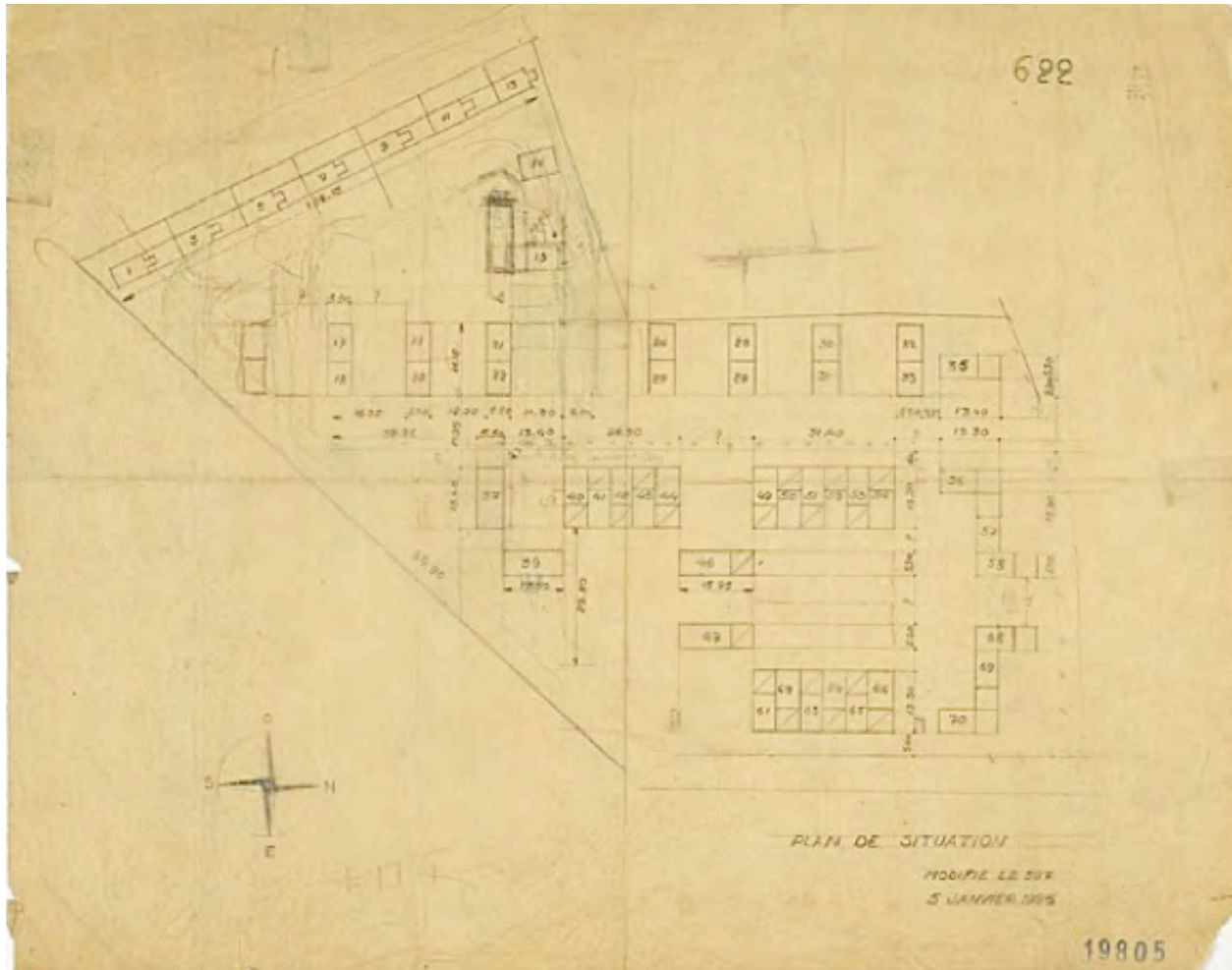


Fig. 125. Le Corbusier. Plan of Sectors C and D, Pessac Settlement, January 5, 1926.
Source: FLC 19805.

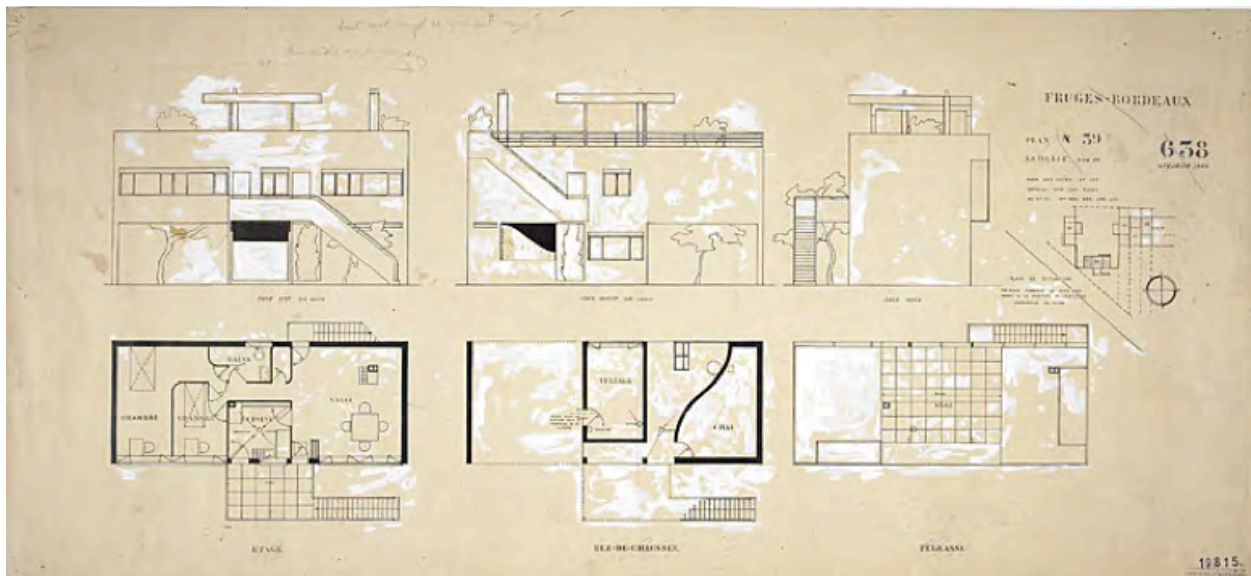


Fig. 126. Le Corbusier. Plan of single family type on parcel 14 (top) and plan of single family type on parcel 39 (bottom), January-February, 1926. See study of parcel 14 and photograph of completed unit on Fig. 127. Sources: FLC 19803; FLC 19815

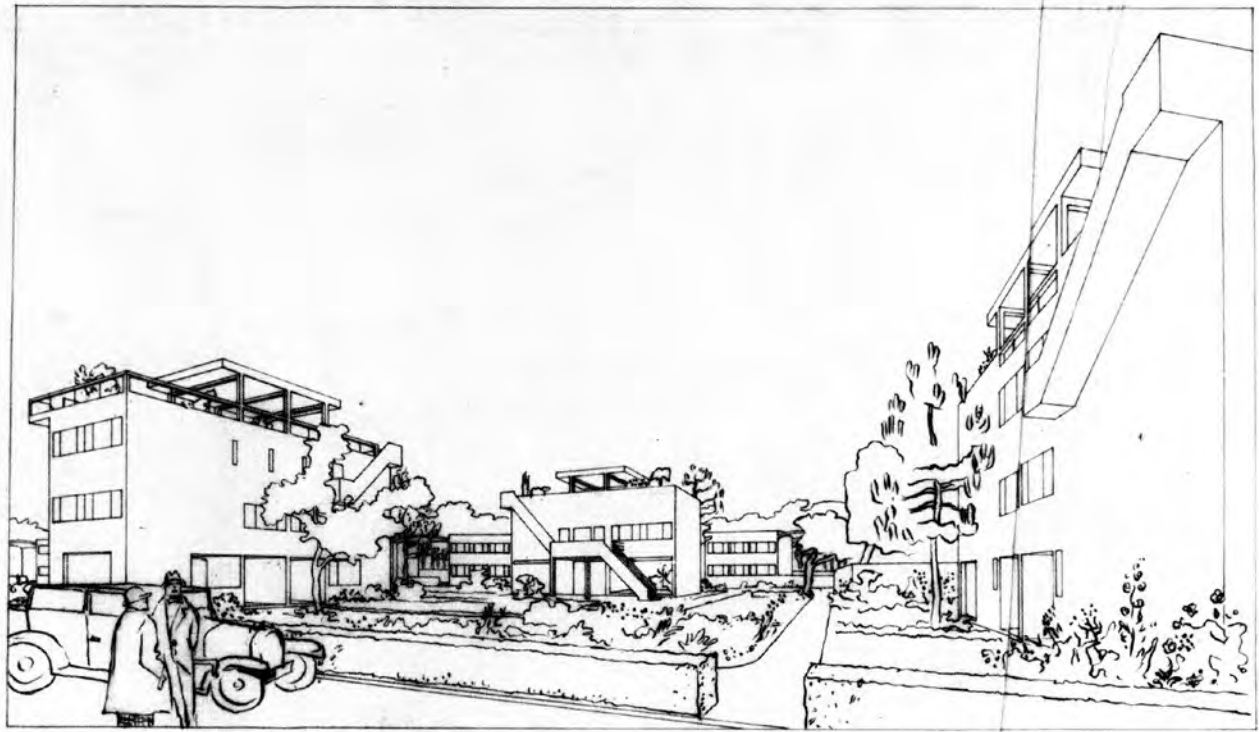


Fig. 127. Le Corbusier. Perspectival study of position of unit and pedestrian path on parcel 14, looking west (top) and photograph of recently renovated unit on parcel 14, looking east (bottom).
Sources: FLC 19859; Author, 2012.

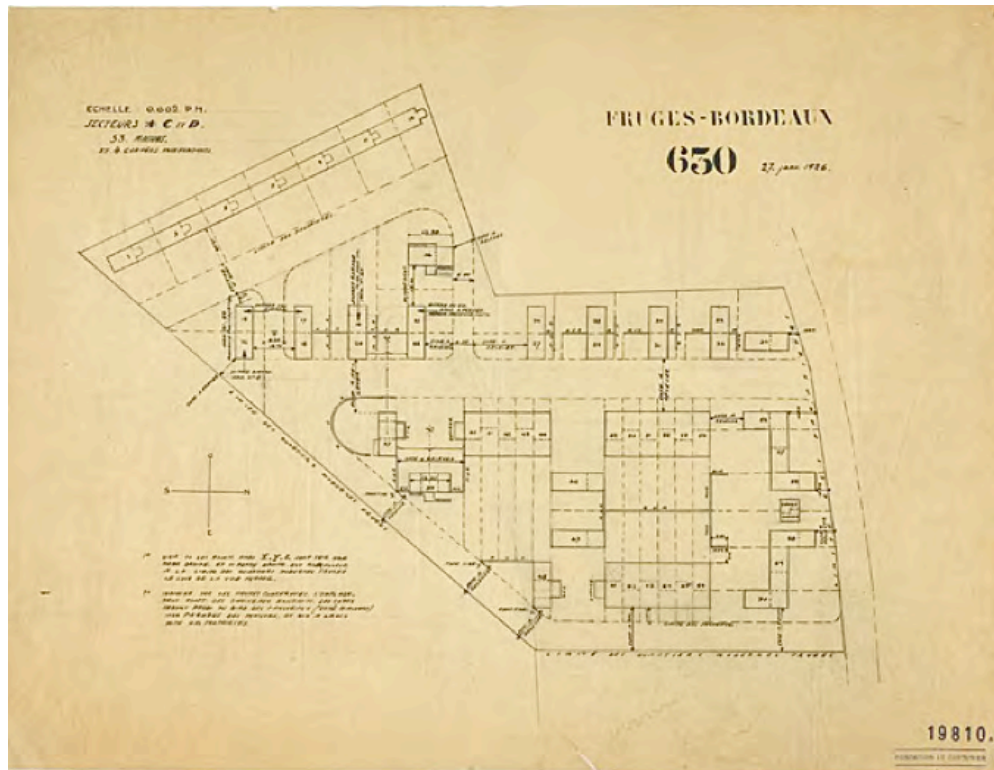


Fig. 128. Le Corbusier. "Fruges-Bordeaux", Pessac Settlement plan, showing final positions of units and traffic corridors, January 27, 1926.
 Source: FLC 19810

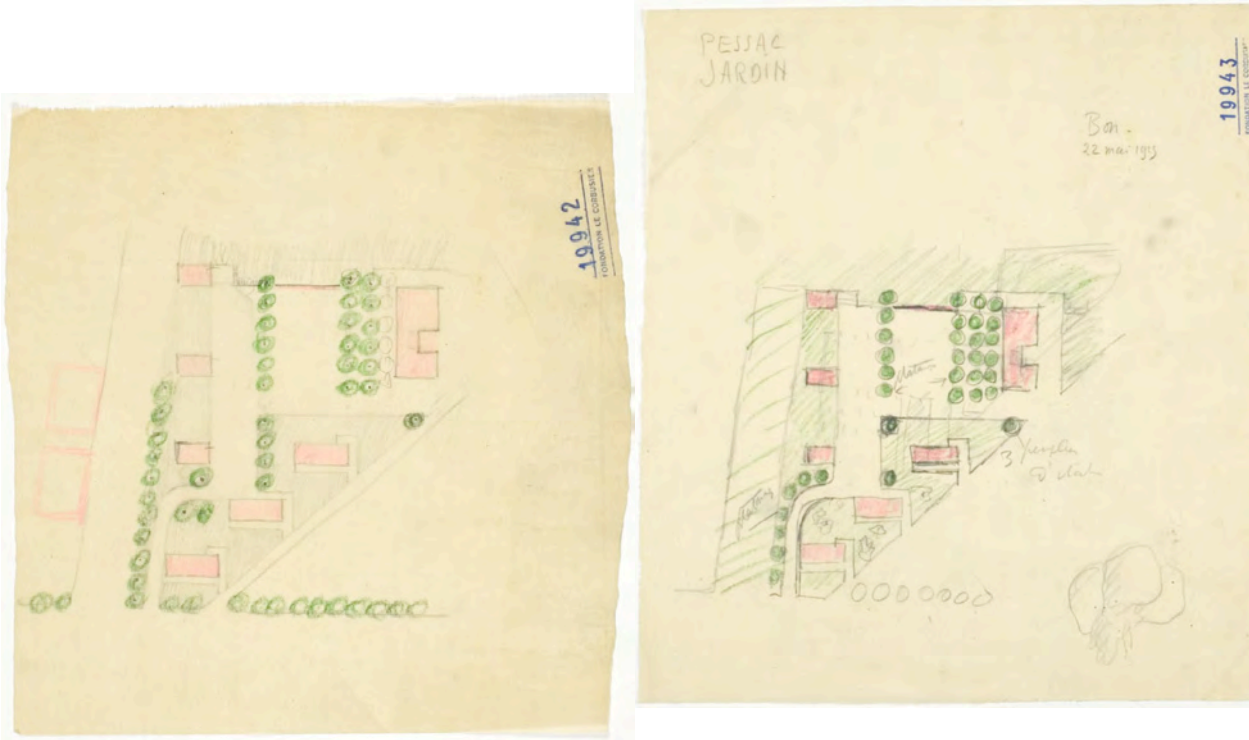


Fig. 129. Le Corbusier. Two variant studies of paving and landscaping of Leges, May 22, 1925.
 Sources: FLC 19942; FLC 19943. (Incorrectly labeled and filed under Pessac)

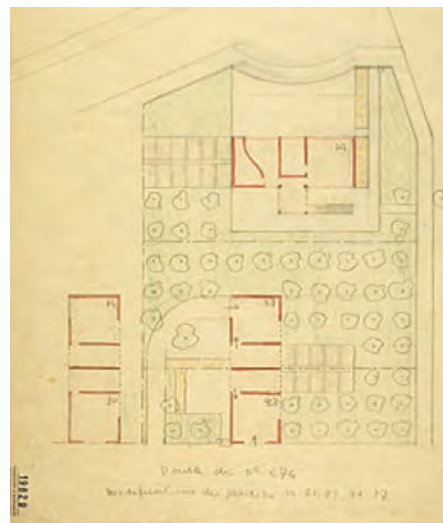
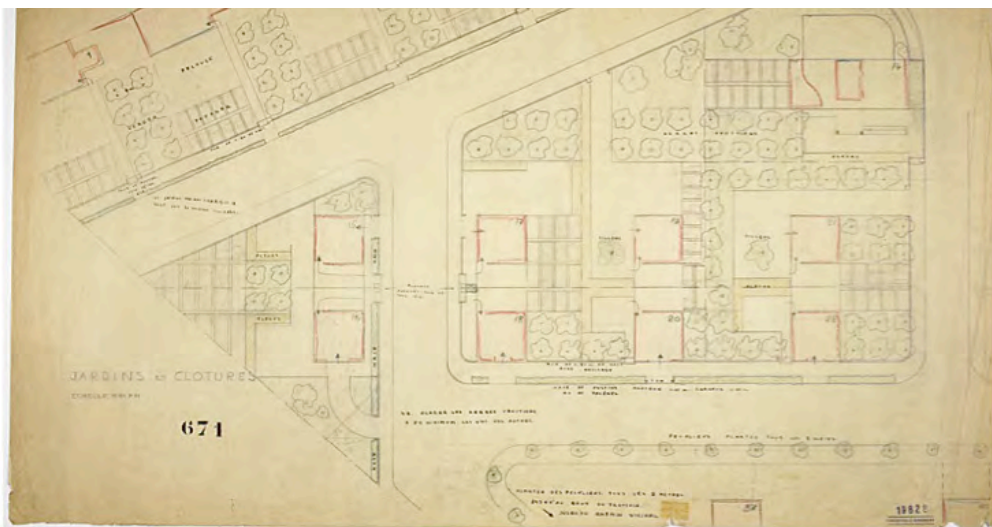
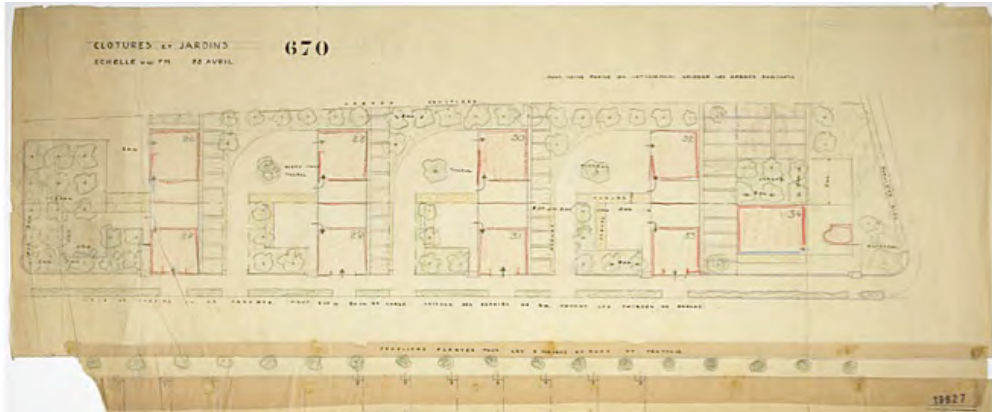


Fig. 130. Le Corbusier. Finalized studies of landscape and hardscape, April 1926.
Sources: FLC 19827; FLC 19828.



Fig. 131. Le Corbusier: Isometric projection of complete Quartiers Moderns Fruges (Sector C and D of Pessac Settlement) (top) and detail of QMF (bottom left) and Cretets (bottom right). See Fig. 86
Source: FLC 19838.

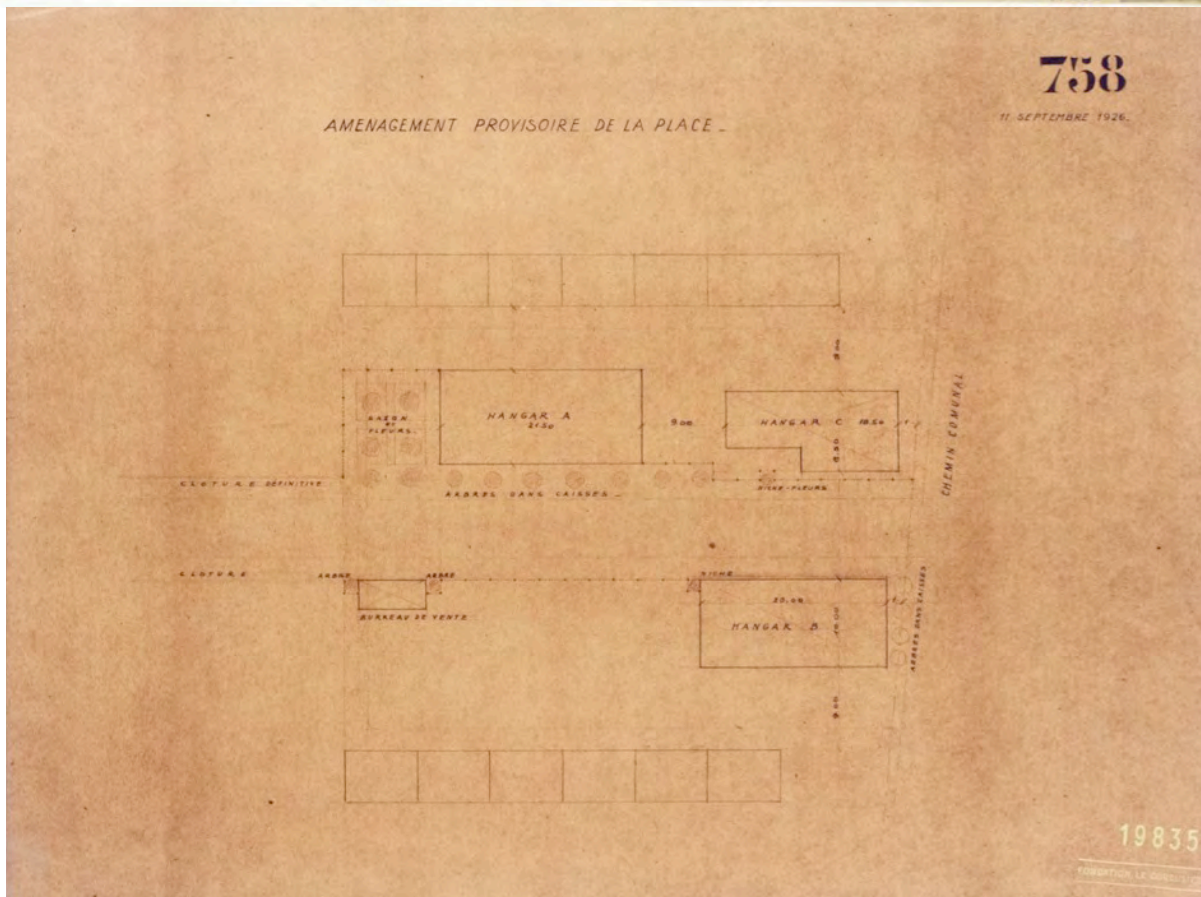
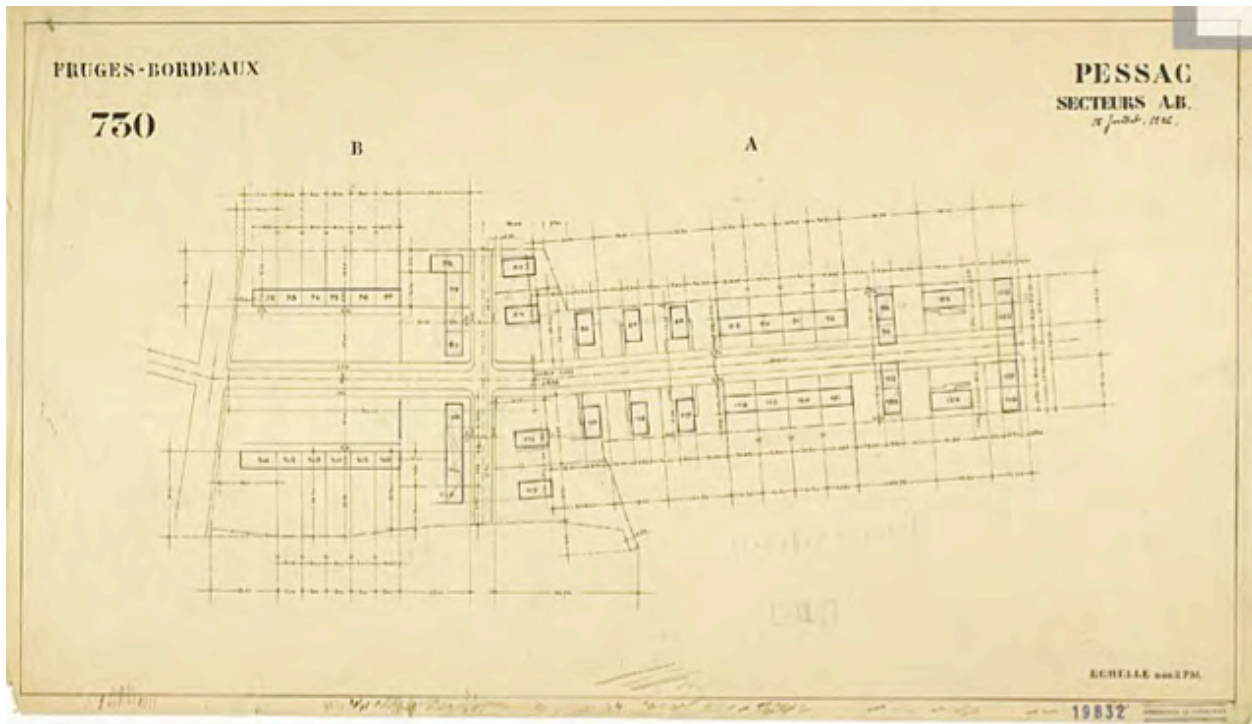


Fig. 132. Le Corbusier: Settlement plan scale study of positions of frames in Sector A and B, September 20, 1926 (top) and temporary construction plant plan, on Sector B's place, September 11, 1926 (bottom). Sources: FLC 19832; FLC 19835.

Chapter 5: Figures



Einfache Wohnstraße in New Earswick bei York (Architekt Unwin).



Einfache Wohnstraße in der Gärtenstadt Heisteria bei Dresden (Architekt Muthesius).

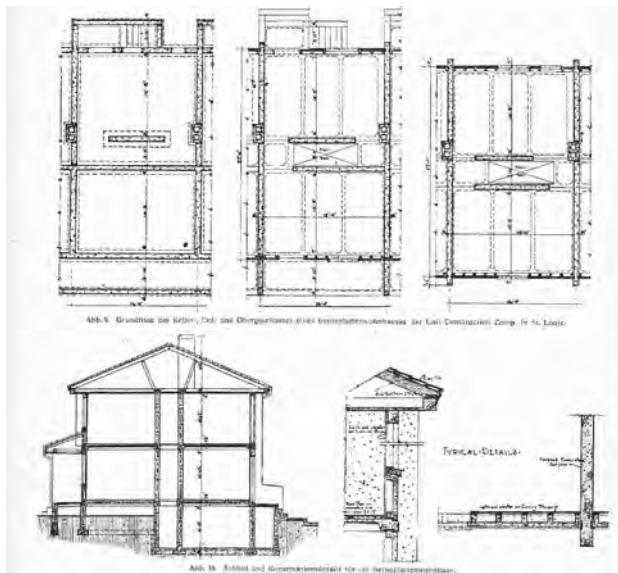


Abb. 9. Grundriss der Keller-, Erd- und Obergeschosse eines Arbeiterwohnhauses der Carl Conzelmann Comp. in St. Louis.

Abb. 10. Schnitt und Außenansicht für ein Arbeiterwohnhaus.

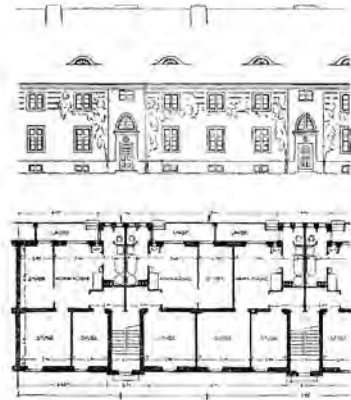


Abb. 11. Versetzen der Deckenplatte auf die gerippten Wandplatten.

Fig. 133. Plates from Martin Wagner's *Wohnungswirtschaft* showing the continued importance of turn of the century settlement designs by Raymond Unwin and Hermann Muthesius (top) as well as the interest in American industrialized settlement building, particularly John Conzelman's Unit System (bottom). Sources: Linneke, Richard. "Die Sparabteilung Der Gemeinnützigen Heimstätten Spar- Und Bau-A.G. In Berlin." *Wohnungswirtschaft* 1, no. 13 (Octobe 1, 1924): 125-29. 125, 127; Wagner, Martin. "Der Rationelle Wohnungsbau." *Wohnungswirtschaft* 1, no. 17/18 (1. Dezember 1924): 159-63. 161, 163.

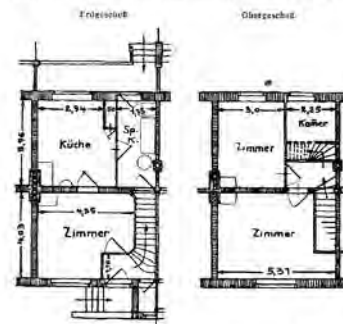


Bebauungsplan der Siedlung „Lindenhof“. Architekt: Stadtbaurat Dr.-Ing. Martin Wagner.

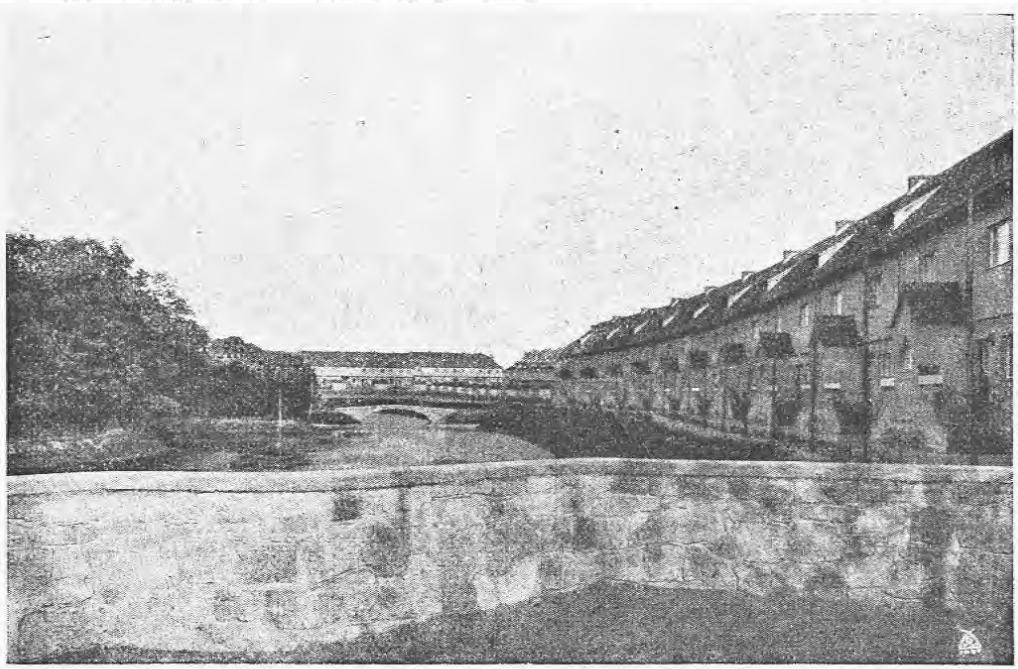


Typ des Vierstöckigen Hauses der Siedlung „Lindenhof“.

spielen ihrer Organisation vermutlich auch viermal im Jahre umzusetzen kann, für sie in der Lage, dem Sparten mindestens halbjährlich die laufenden Zinsen zum Kapital zu schlagen.



Typ eines Zweifamilienhauses der Siedlung „Lindenhof“. Architekt: Stadtbaurat Dr.-Ing. Martin Wagner.



Einfamilienhäuser am Weiher. Architekt: Stadtbaurat Dr.-Ing. Martin Wagner.

Fig. 134. Plates from *Wohnungswirtschaft* showing settlement plan, elevations, unit plans and photograph of Martin Wagner's Lindenhof Settlement in Berlin (1918-1920), where Gilbreth's Bricklaying System was first applied in Europe.

Source: Wagner, Martin. "Vom Eigenen Werk. (Siedlung "Lindenhof" in Berlin-Schöneberg)." *Wohnungswirtschaft* 1, no. 1-2 (1. April 1924): 8-9.

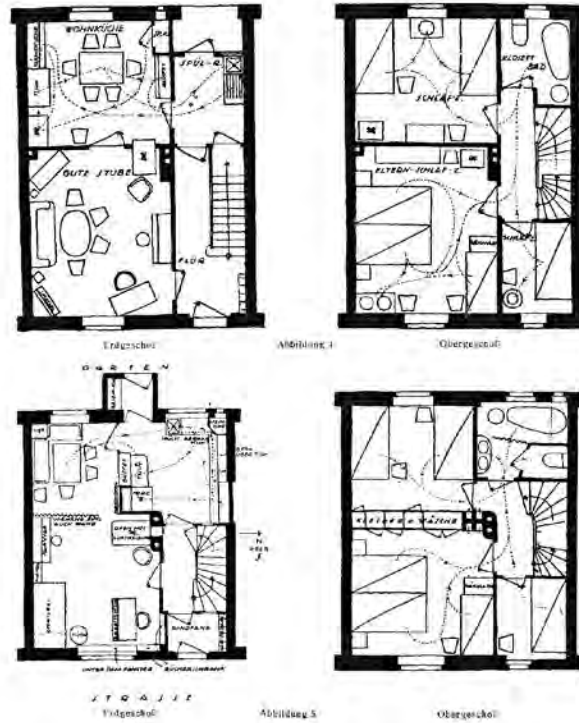


Fig. 135. Plates from *Wohnungswirtschaft* showing Bruno Taut's studies of the routing of activates in row-house units, later reproduced in American journals.
 Source: "Wie Soll Der Kleinwohnungsbau Der Minderbemittelten Volksklassen Finanziert Werden?". *Wohnungswirtschaft* 1, no. 3 (1 May 1924): 17-23. 22.

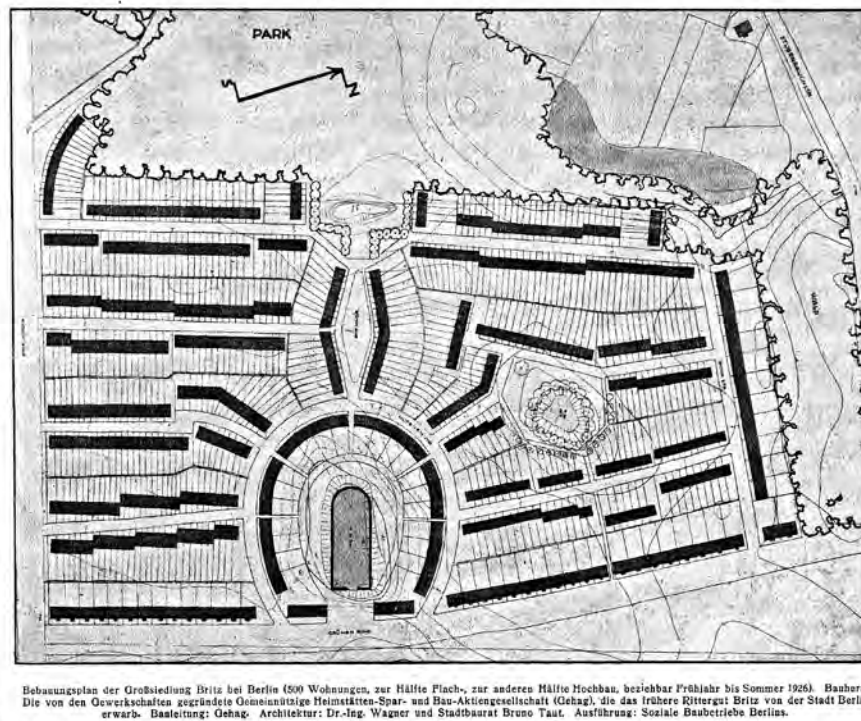


Fig. 136. Plate from Wagner's *Soziale Bauwirtschaft* showing Wagner and Taut's Britz Settlement in Berlin, 1925.
 Source: "Gewerkschaften Fordert Die Gemeinwirtschaft!". *Soziale Bauwirtschaft* 5, no. 17/18 (September 1, 1925): 22-24. 23

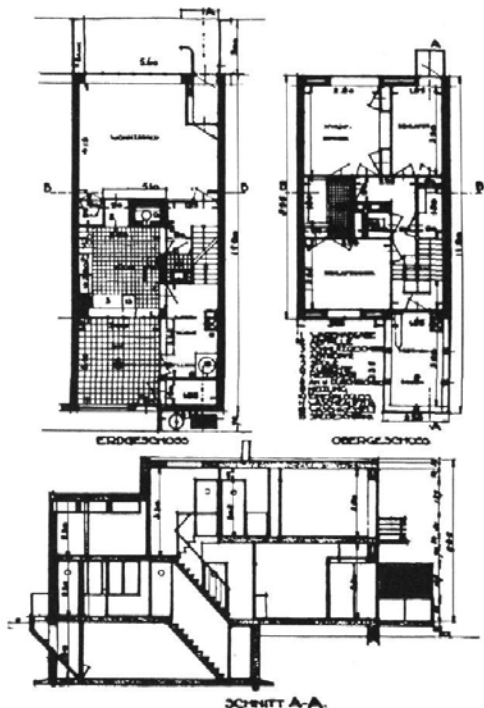
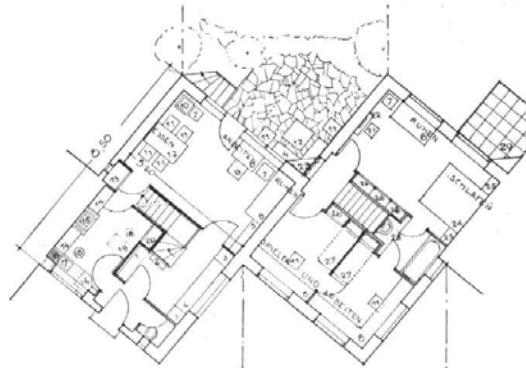


Abb. 9 bis 11 | Reihenhäuser für die Ausstellung „Die Wohnung“ in Stuttgart
Architekt: J. J. P. Oud, Rotterdam



Bei Fortfall der sägeförmigen Anordnung werden Bad und Treppe wie bei Oud nicht mehr unmittelbar belüftet.

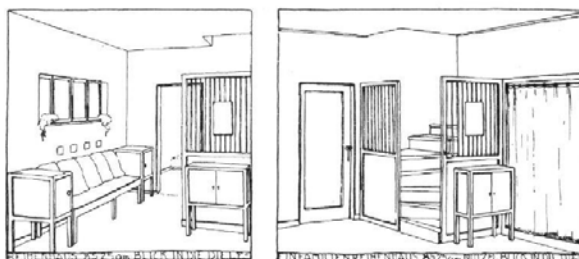


Abb. 12 bis 14 | Studie zu Reihenhäusern gleicher Größe wie in Abb. 9 bis 10
Architekt: Alexander Klein, Berlin

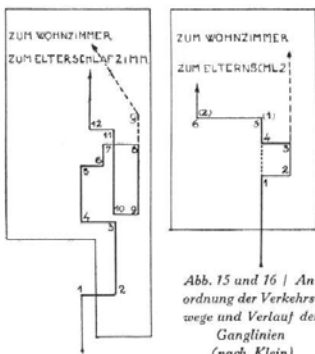


Abb. 15 und 16 | Anordnung der Verkehrswege und Verlauf der Ganglinien (nach Klein)

Die Ganglinien links zeigen (bei Oud) vom Hof ins Wohnzimmer 9, vom Hof ins Schlafzimmer 12 Windungen. Der Hofeingang ist gewählt, weil er laut Lageplan (Abb. 30) zugleich Straßeneingang ist; der zweite Eingang ist nur durch den Garten erreichbar.

Die Ganglinien rechts (bei Klein) haben nur 2 und 6 Windungen; da die Wendung der Treppe (Abb. 12) fortfallen kann, ist weitere Vereinfachung (schwach gestrichelt) möglich.

Vgl. Text Seite 296 und 298

Untersuchung der Bewegungsflächen auf Obergeschoß beschränkt, weil Möbel bei Oud nicht eingetragen (Abb. 9 und 10); die Bettstellung durch Türen u. Fenster festgelegt.

Links (bei Oud) Mangel an größeren Bewegungsflächen, Zerrissenheit, verwickelter Zusammenhang.

Rechts (bei Klein) Konzentration größerer Bewegungsflächen bei guter Anordnung, Beleuchtung und bequemer Verbindung (Fortfall des winkligen Flures).

Vgl. Text Seite 296 und 298

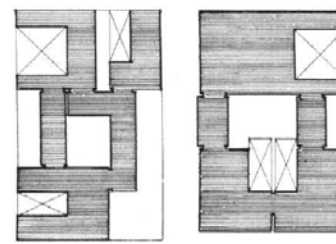


Abb. 17 und 18 | Konzentration der Bewegungsflächen in den Obergeschossen (nach Klein)

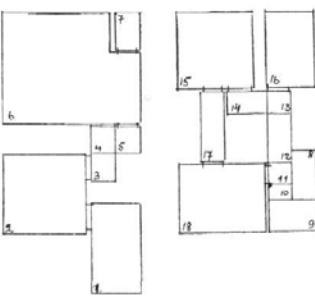


Abb. 19 bis 22 | Geometrische Ähnlichkeit und Zusammenhang der Grundrißelemente (nach Klein)

Links (bei Oud) im Erd- und Obergeschoß 18 Elemente verschiedener Rechteckform und Größe, immer wieder andere Längsrichtungen.

Rechts (bei Klein) im Erd- und Obergeschoß nur 11 Elemente, deren Form, Größe und Richtung untereinander ähnlich oder gleich sind (z. B. 2 und 4, 10 und 11, 7 und 9). Die Darstellungen für Klein sind spiegelverkehrt gezeichnet.

Vgl. Text Seite 296 und 298

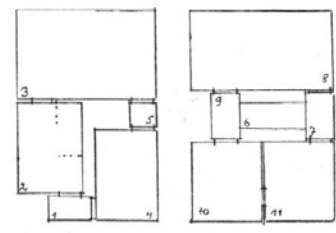
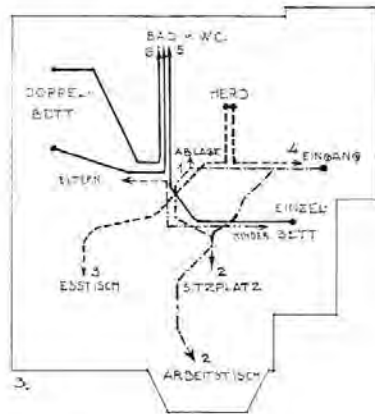


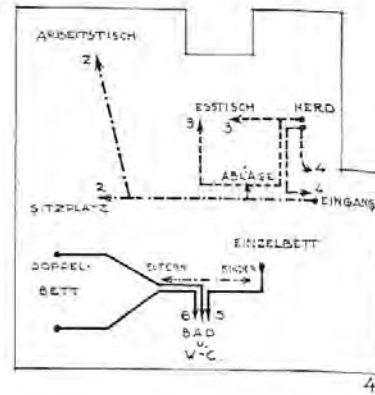
Fig. 137. Page from Alexander Klein's "Versuch Eines Graphischen Verfhahrens Zur Bewertung Von Kleinwohnungs Grundrissen," demonstrating his "experimental" mode of graphic analysis through a study of J. P. Oud's work at the Weißenhofsiedlung.
Source: Klein, Alexander. "Versuch Eines Graphischen Verfhahrens Zur Bewertung Von Kleinwohnungs Grundrissen." *Wasmuths* (April 1927): 296-98.

ALEXANDER KLEIN



161. Ganglinien im ausgeführten Beispiel.

Die Wege sind sehr verwickelt und schneiden sich in mehreren Punkten. Länge der Linien: 1. 1,10 m, 2. 8,2 m, 3. 8 m, 4. 4,20 m, 5. 8,50 m, 6. 8 m; zusammen also 41 m.

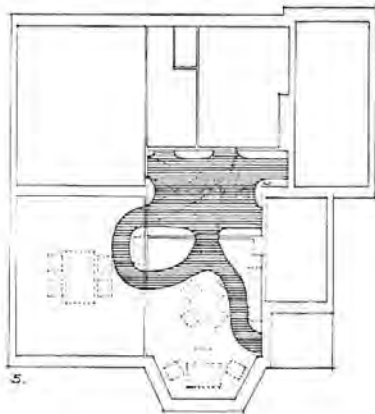


162. Ganglinien im Gegenvorschlag.

Die drei Hauptvorgänge: Kochen-Essen, Wohnen-Ruhen, Schlafen-Waschen können sich gleichzeitig ungestört abwickeln. Die Ganglinien schneiden sich nicht. Länge der Linien: 1. 2,30 m, 2. (im Durchschnitt) 4,50 m, 3. (ditto) 2,35 m, 4. (ditto) 3,20 m, 5. 3,20 m, 6. 10,90 m, zusammen 26,45 m.

163. Verkehrsfläche im ausgeführten Beispiel.

Fast die ganze Fläche der Diele dient dem Verkehr. Die Aufstellung der in Abb. 159 vorgesehenen Möbel ist nicht möglich; der Gang zur Laube ist beengt und umständlich. Das Vorbeigehen belästigt die Sitzenden.



164. Verkehrsflächen im Gegenvorschlag.

In der Diele wird nur ein Streifen für den Verkehr benötigt. An den Wänden können Möbel gestellt werden. Der Zugang zur Laube ist geradlinig und frei. Keine Möbelstücke brauchen umgangen zu werden.

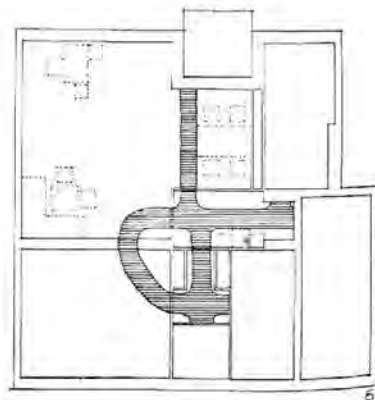
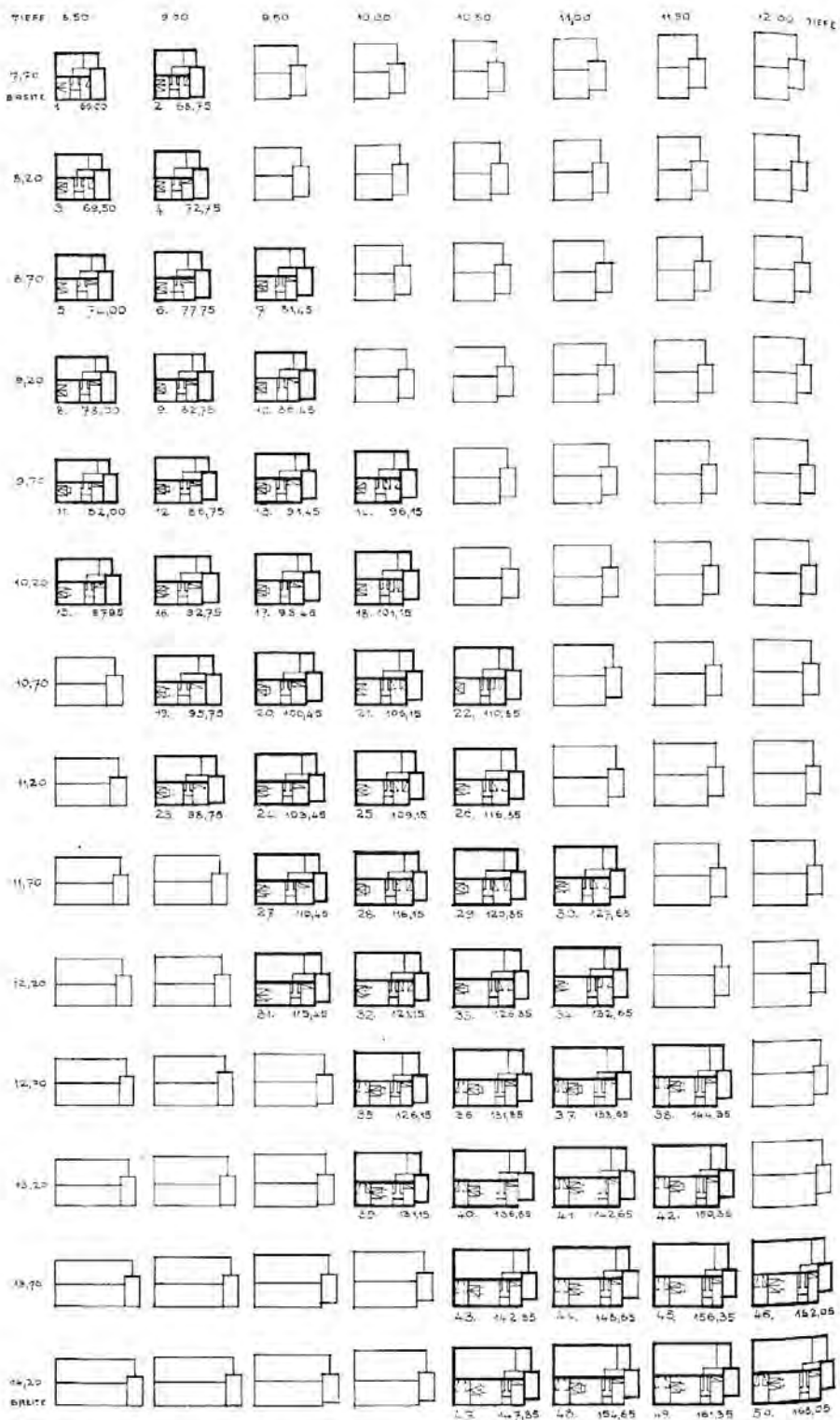


Fig. 138. Page from Alexander Klein's "Beitrage Zur Wohnungsfrage," demonstrating his "experimental" mode of graphic analysis through a study of a typical Berlin apartment as well as demonstrating the use of this analysis as a mode of projection, through a new, more "objective" unit.

Source: Klein, Alexander. "Beitrage Zur Wohnungsfrage." In *Probleme Des Bauens*, edited by Fritz Block, 116-45. Potsdam: Müller & Kiepenheuer, January 1928. 138.



134 158. Schema der rationellen Grundrißbildung für einen beliebigen Typ in verschiedenen Wohnverhältnissen (vergl. Text Seite 133)

Fig. 139. Page from Alexander Klein's "Beitrage Zur Wohnungsfrage," demonstrating how his analytical system can generate optimal floor plan configurations.

Source: Klein, Alexander. "Beitrage Zur Wohnungsfrage." In *Probleme Des Bauens*, edited by Fritz Block, 116-45. Potsdam: Müller & Kiepenheuer, January 1928. 134

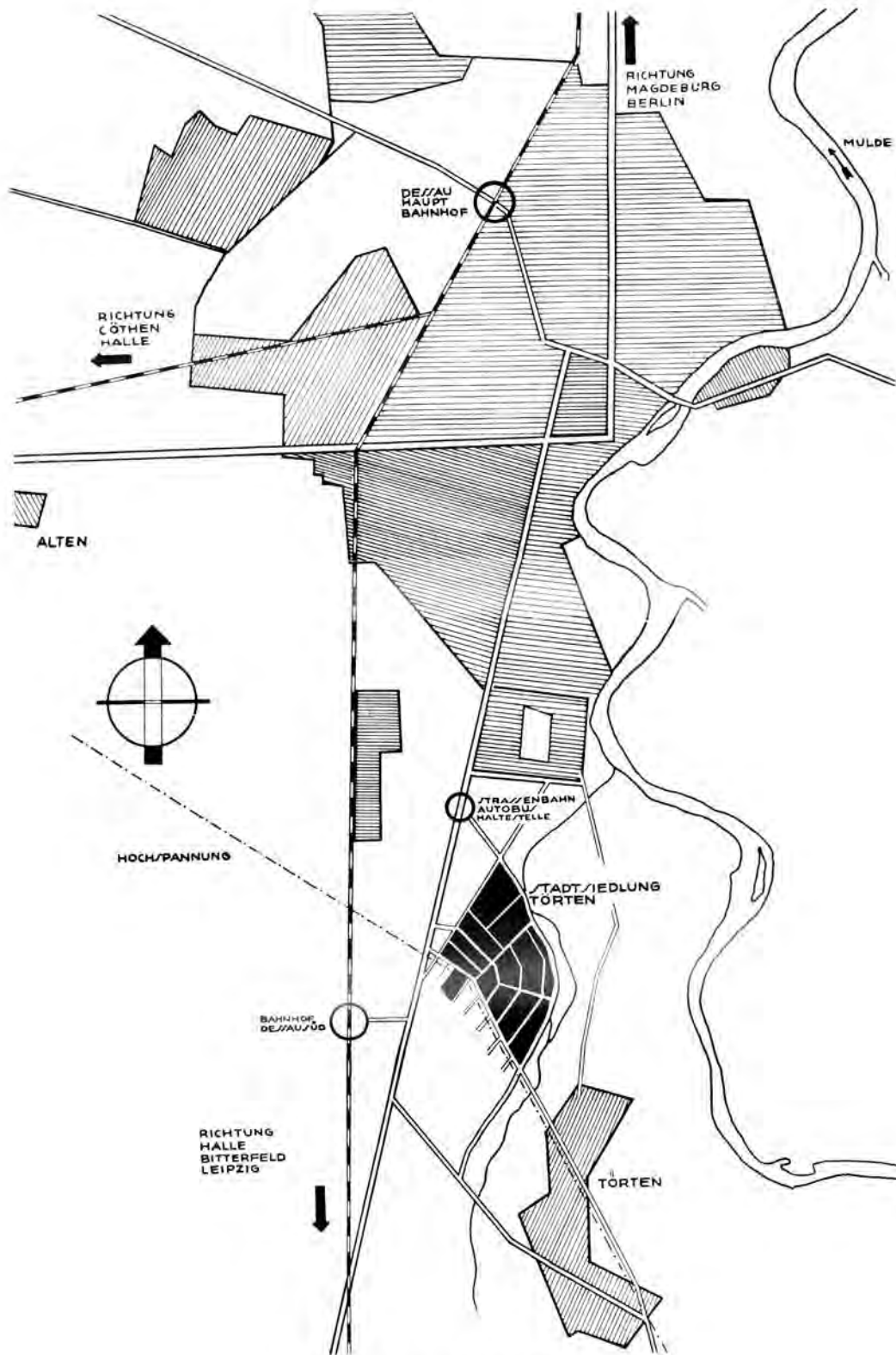


Abbildung 1. Lage der Siedlung zur Stadt Dessau.

Fig. 140. Plate from the April 1929 RFG report on Walter Gropius's municipal settlement Torten, in Dessau, showing location of settlement (in black) in relation to the existing town infrastructure and development. Source: "Bericht Über Die Versuchssiedlung in Dessau." *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen Sonderheft Nr. 7*, no. Gruppe IV NR. 4 (April 1929).

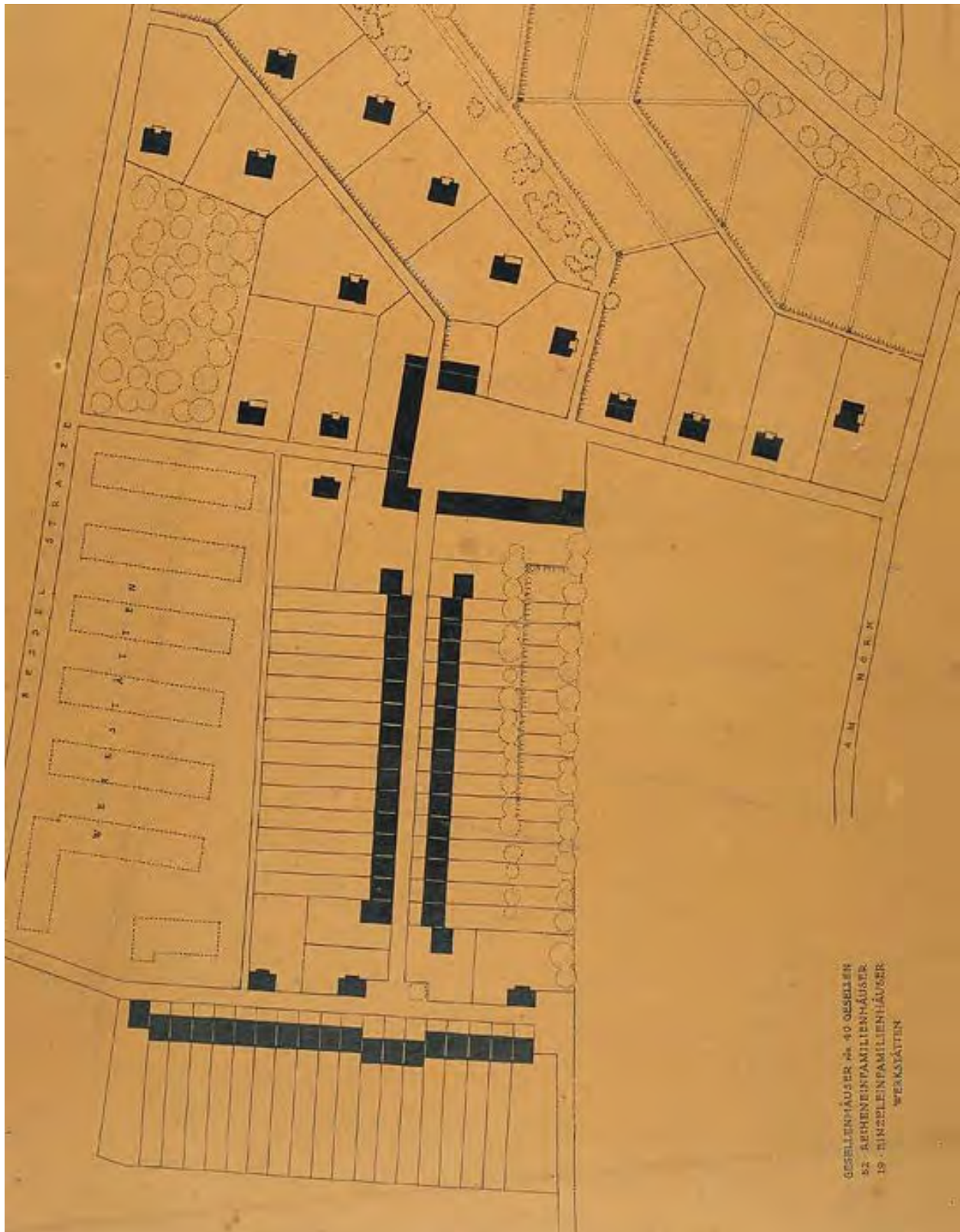
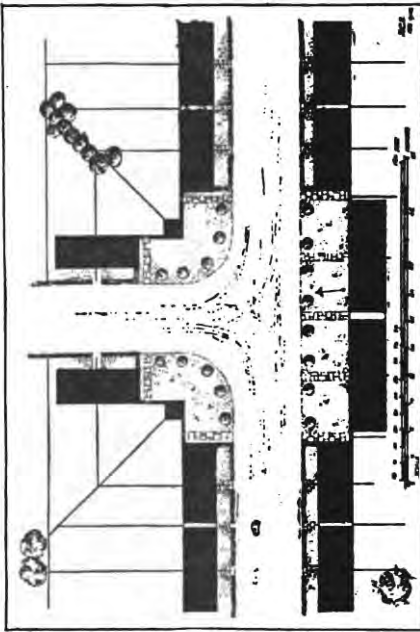


Fig. 141. Fred Forbat and Walter Gropius. Bauhaus Settlement "Am Horn", Weimar, 1920-22.
Source: HAM/B-RM BRGA.12.1



Illus. 244.—Alternative arrangement where greens are left at the corners.



Illus. 245.—Sketch showing effect of junction planned as Illus. 244.

Fig. 144. Plates from Town Planning in Practice showing organizational scheme for a t-junction intersection (left) and a perspective showing the potential resolution of the intersection (right).

Source: Unwin. *Town Planning in Practice*, 1909. 332, 333.

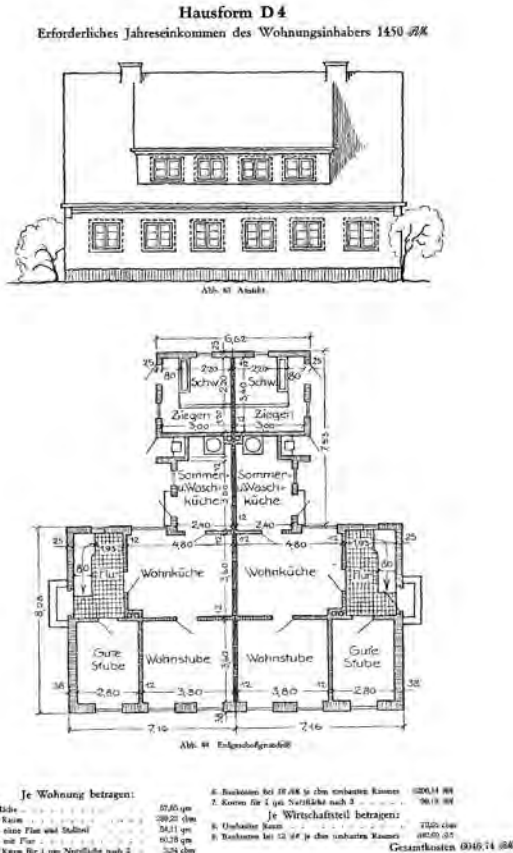


Fig. 145. Page from Lübbert, *Rationeller Wohnungsbau: Typ/Norm*, showing "Hausform D4" a type had been normed.

Source: Lübbert, Wilhelm. *Rationeller Wohnungsbau: Typ/Norm* [Rational House-Building: Type/Norm]. Berlin: Arbeitsgemeinschaft für Rationalisierung im Bauwesen/Beuth Verlag 1926. 106.

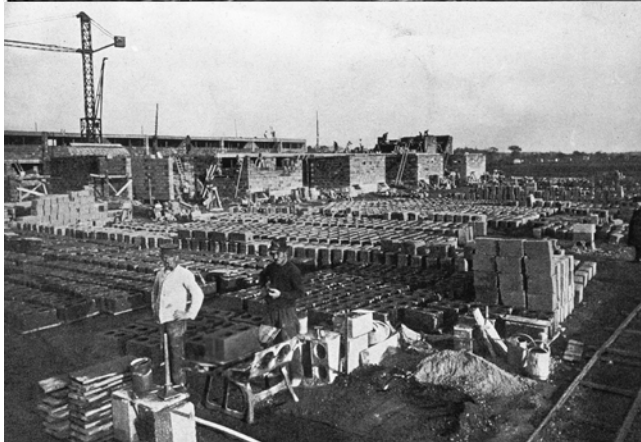


Fig. 147. Walter Gropius. Progress photos of Torten, Phase I, 1926.

Sources: Gropius, Walter. *Bauhausbauten - Dessau*. Bauhausbücher. Vol. 12, Munich: Albert Langen, 1930; "Der Grosse Baukasten." *Das Neue Frankfurt* 2 (December 1926): 25-29; "KG316 Building Site." Harvard University: Loeb Library, Harvard Design School, 1926.



Fig. 148. Walter Gropius. Aerial view of Törten, Phase I, 1926.
Source: Gropius, Walter. *Bauhausbauten - Dessau*, 1930. 159.

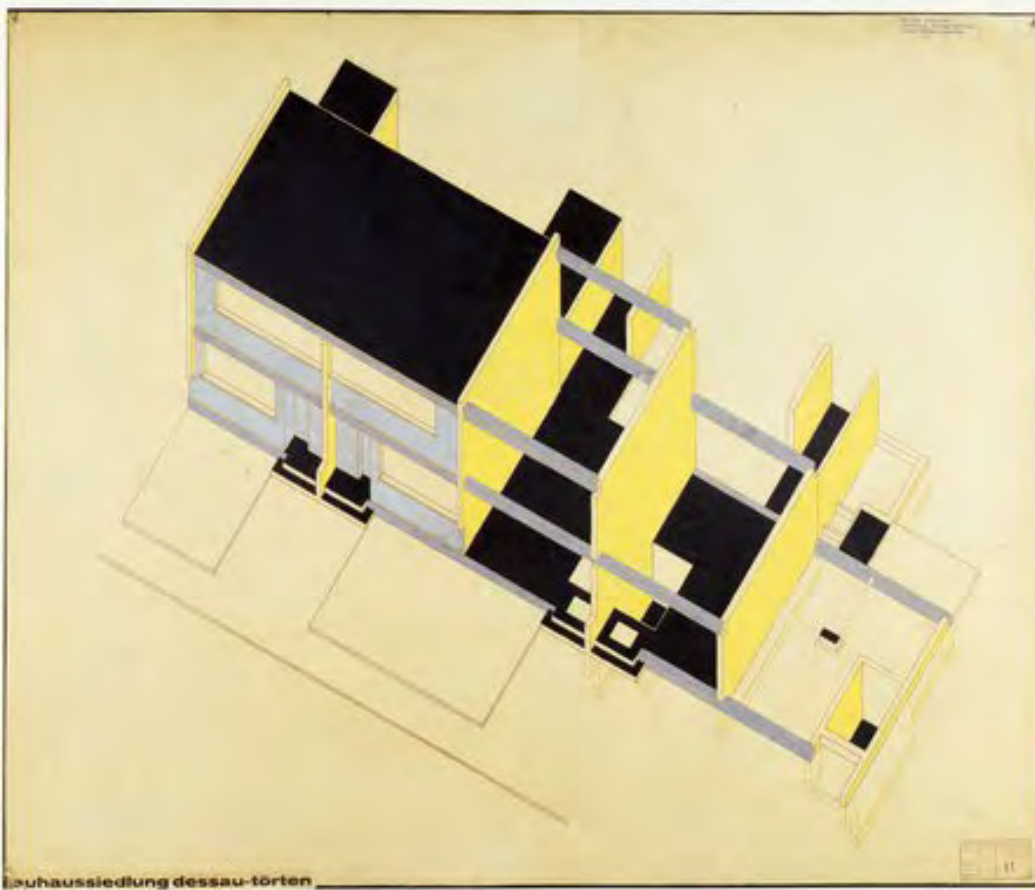
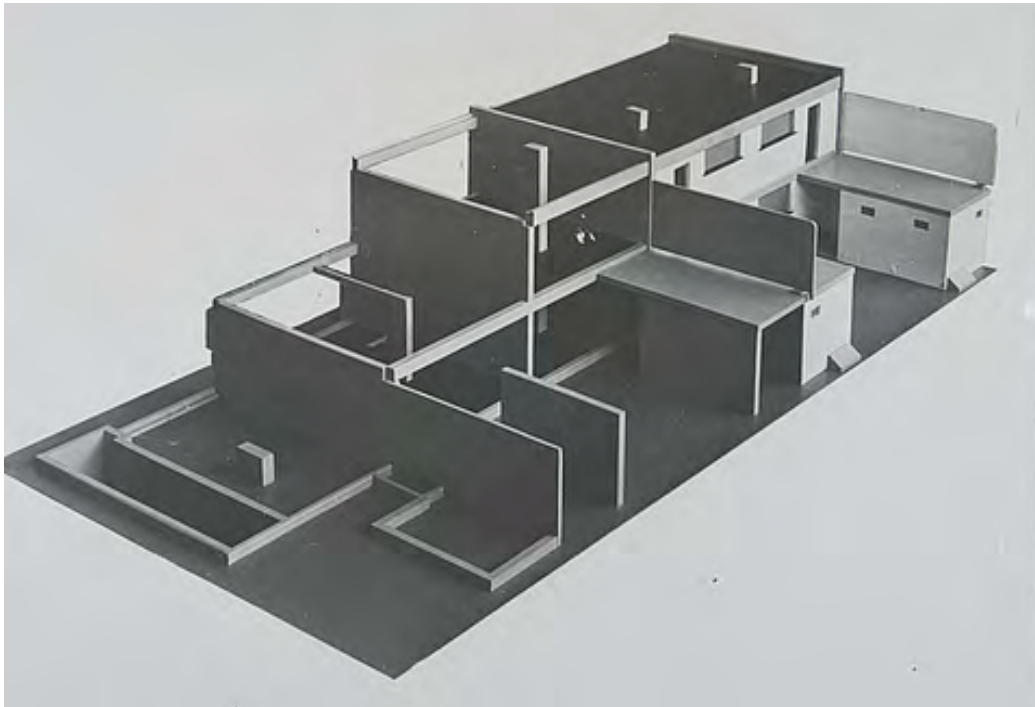
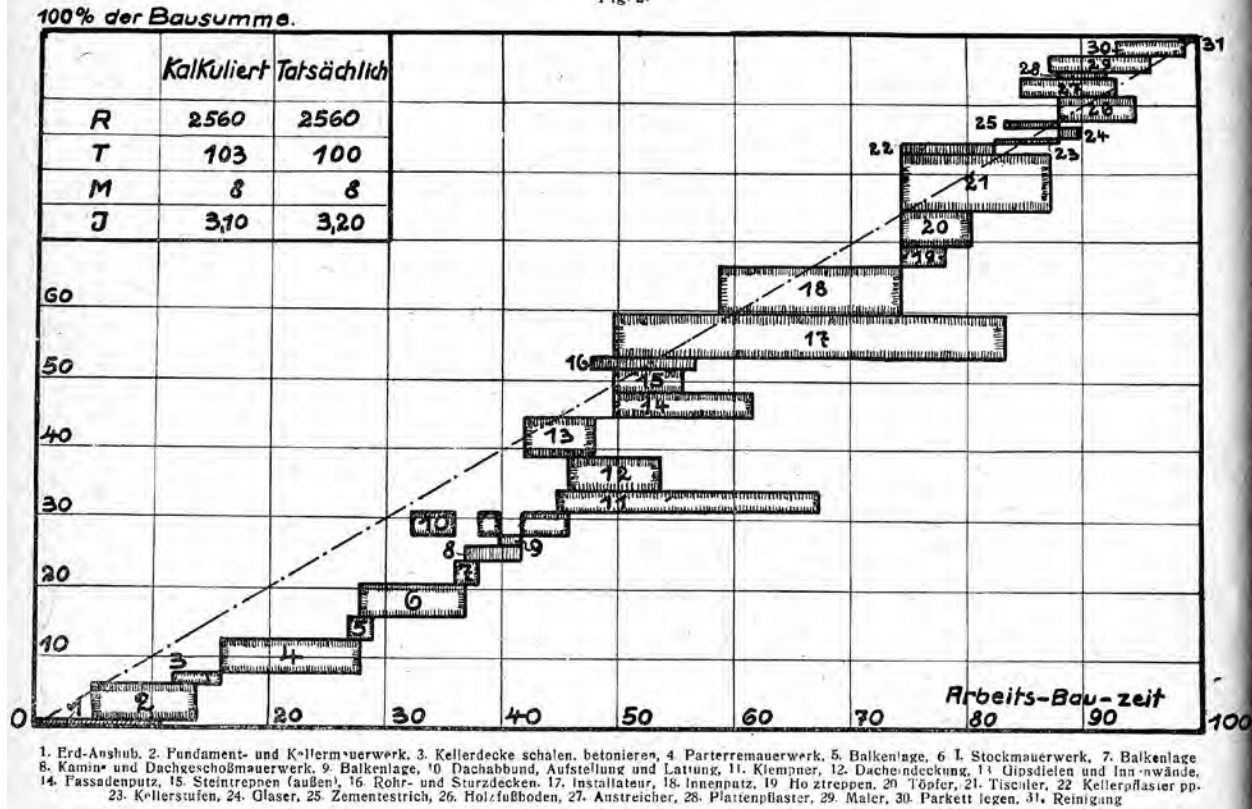


Fig. 149. Walter Gropius. Model (top) and isometric study (bottom) of Type I, Törten, 1926.
Sources: HAM/B-RM BRGA.22.64; HAM/B-RM BRGA.22.67.

Das Arbeitsgraphikon.

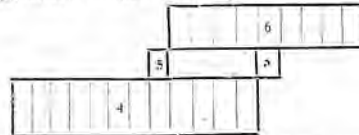
Fig. 2.



Nr.	Art der Arbeit	Datum		Zahl d. Arbeitstage	% Satz von der Bau Sa
		Anfang	Ende		
1	Aushub	9. 6.	22. 6	11	0.80
2	Fund.- u. Kellermauerwerk	15. 6	26. 6	9	5.50
3	Kellerdecke schalen, beton.	24. 6.	28. 6	4	1.80
4	Parterremauerwerk	30. 6.	13. 7.	12	4.60
5	Balken legen	12. 7.	14. 7.	2	3.20
6	I. Stockmauerwerk	14. 7.	24. 7.	9	4.70
7	Balken legen	24. 7.	25. 7.	2	3.25
8	Kamin- u. Dachbodenmauerwerk	25. 7.	29. 7.	5	2.20
9	Dachabbund.	28. 7.	29. 7.	2	1.20
10	Dachaufstellung und Lattung	31. 7.	31. 8.	4	3.20
11	Klempner.	2. 8.	25. 8	24	3.60
12	Dacheindeckung	4. 8.	12. 8.	8	5. —
13	Gipsdielen und Innenwände	31. 7.	5. 8	6	5.40
14	Fassadenputz.	7. 8.	21. 8	12	3.50
15	Steinstiegen versetzen	7. 8.	12. 8	6	3.50
16	Rohr- und Sturzdecken	4. 8.	14. 8	9	2. —
17	Installateur (Gas—Wasser)	7. 8.	16. 9	32	6. —
18	Innenputz	16. 8.	2. 9	16	7. —
19	Holzstiegenaufstellung	4. 9.	7. 9.	4	3. —
20	Töpfer	4. 9.	11. 9	6	5. —
21	Tischler	4. 9.	20. 9.	14	8.50
22	Pflaster, Keller, Boden	4. 9.	12. 9	8	1.50
23	Kellerstufen	13. 9.	19. 9.	6	0.55
24	Glaser	20. 9.	22. 9.	3	1.60
25	Zementestrich	15. 9.	20. 9.	5	0.80
26	Fußboden (weich)	21. 9.	30. 9.	8	3.60
27	Anstreicher	16. 9.	26. 9.	9	3. —
28	Plattenpflaster	21. 9.	25. 9.	4	0.40
29	Maler	20. 9.	30. 9.	10	2.80
30	Parketten legen	2. 10.	7. 10.	6	2.70
31	Reinigung	6. 10.	9. 10.	2	0.10

Berichtigung.

In der vorigen Nummer der „Sozialen Bauwirtschaft“ ist beim Abdruck des Aufsatzes „Wissenschaftliche Arbeitsmethoden im Baugewerbe“ von Ing. Otto Rode auf Seite 4, links unten, ein Versehen unterlaufen. Die dort mit Figur 3 bezeichnete Skizze ist nur eine Teilzeichnung aus Figur 2 (Graphikon). Die nach dem entsprechenden Text erforderliche Figur 3 ist aus Versehen weggelassen worden und muß folgendermaßen aussehen:



Wir bitten unsere Leser, die betreffende Stelle unter Beachtung dieser Figur noch einmal nachzulesen.

Fig. 150. Plates from Otto Rode's "Wissenschaftliche Arbeitsmethoden im Baugewerbe" explaining the use of a gantt chart through a specific settlement project (top) and through an instruction card (bottom left) and a diagram explaining the principle of task interdependencies (bottom right).

Source: Rode, Otto. "Wissenschaftliche Arbeitsmethoden Im Baugewerbe." *Soziale Bauwirtschaft* 4, no. 1 (1 Jan 1924): 3-6.

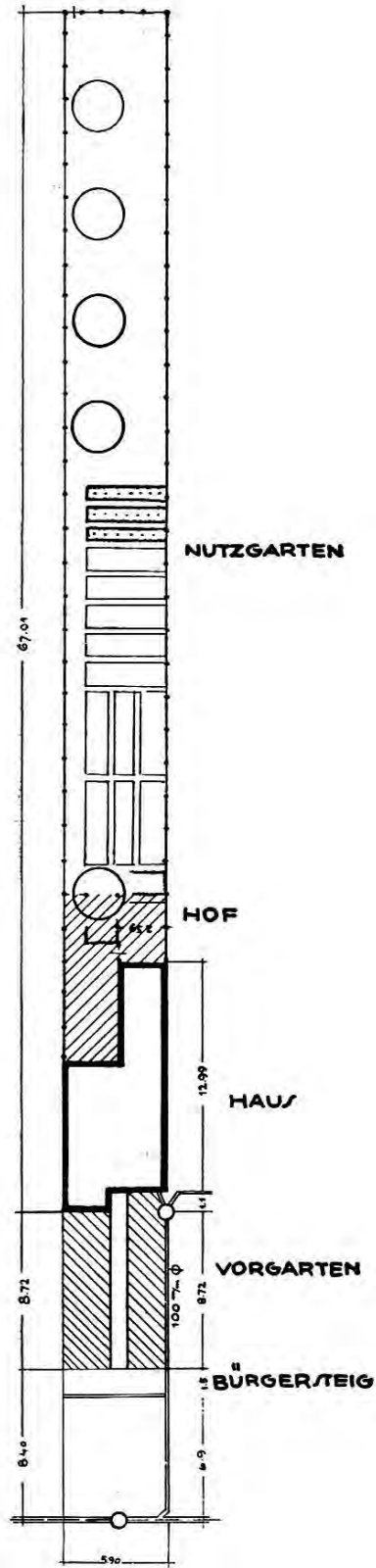


Bild 3. Grundstück für Typ Sietö I a.

Fig. 153. Walter Gropius. Parcel plan for Type I, showing landscape design, Torton, 1926.
 Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).

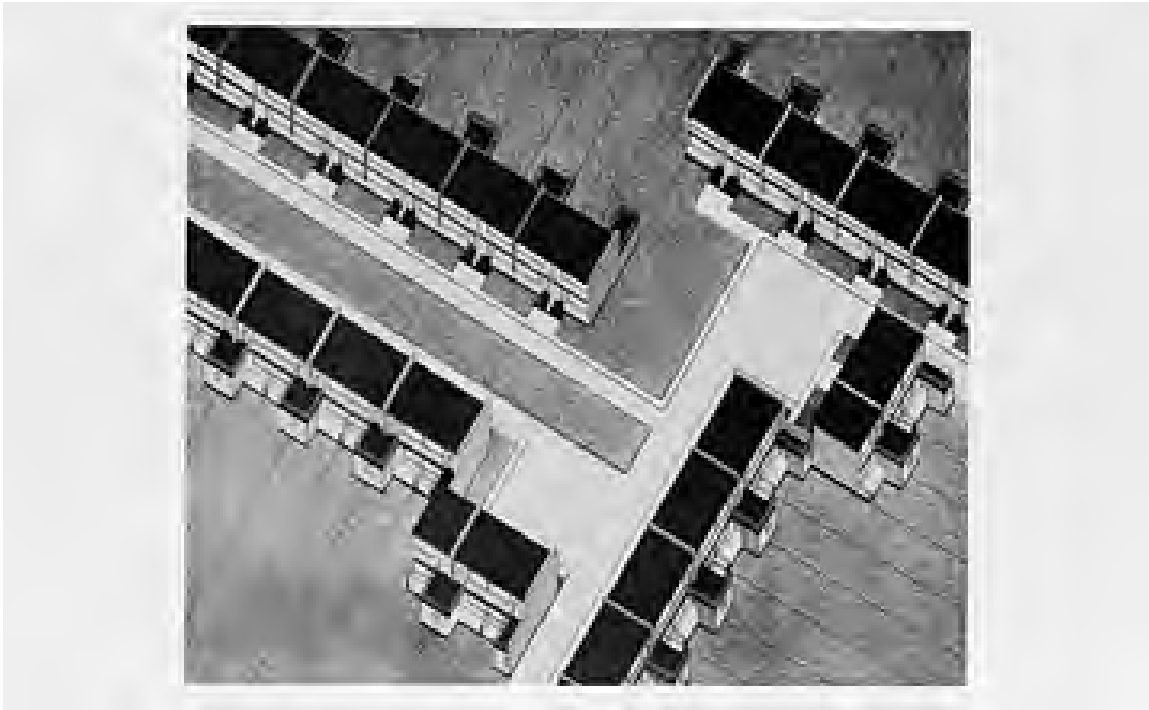


Fig. 154. Plate from Gropius, "Der Grosse Baukasten," studying the potential grouping of Type I (top) and a photograph of the grouping of Type I, at Torten, in 1926-27 (bottom).
Sources: Gropius, "Der Grosse Baukasten." *Das Neue Frankfurt 2* (December 1926): 25-29; HAM/B-RM BRGA.22.84.



Fig. 155. Walter Gropius. Micromotion studies of experimental unit of Törten Phase I, 1926. Source: Gropius. *Bauhausbauten - Dessau*, 1930. 174, 175.

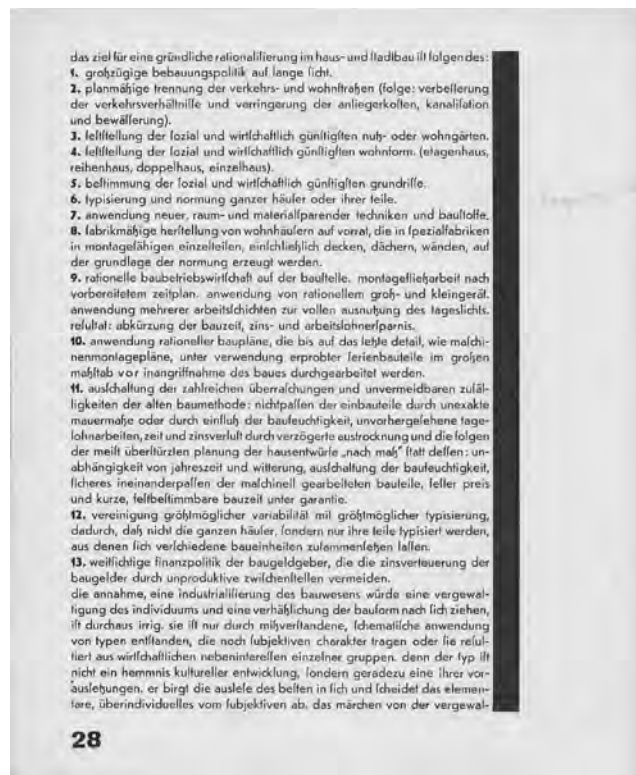


Fig. 156. Walter Gropius. Sequence of tasks for settlement-building, December 1926. Source: Gropius, "Der Grosse Baukasten." *Das Neue Frankfurt 2* (December 1926): 25-29

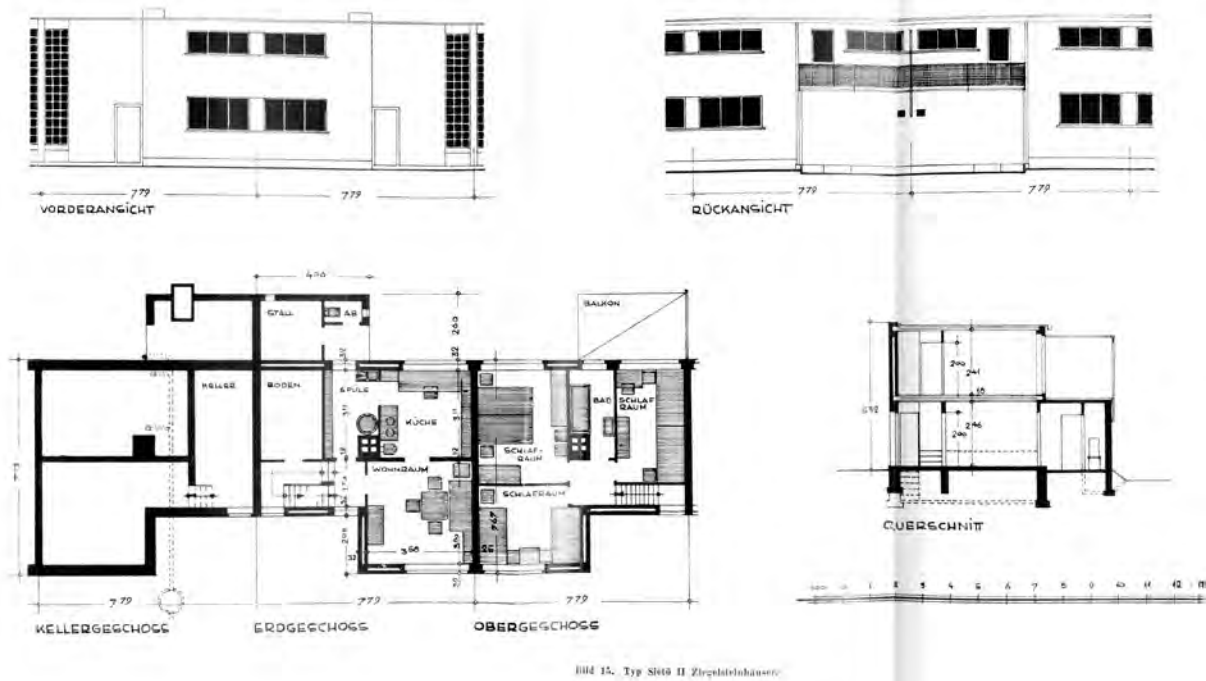
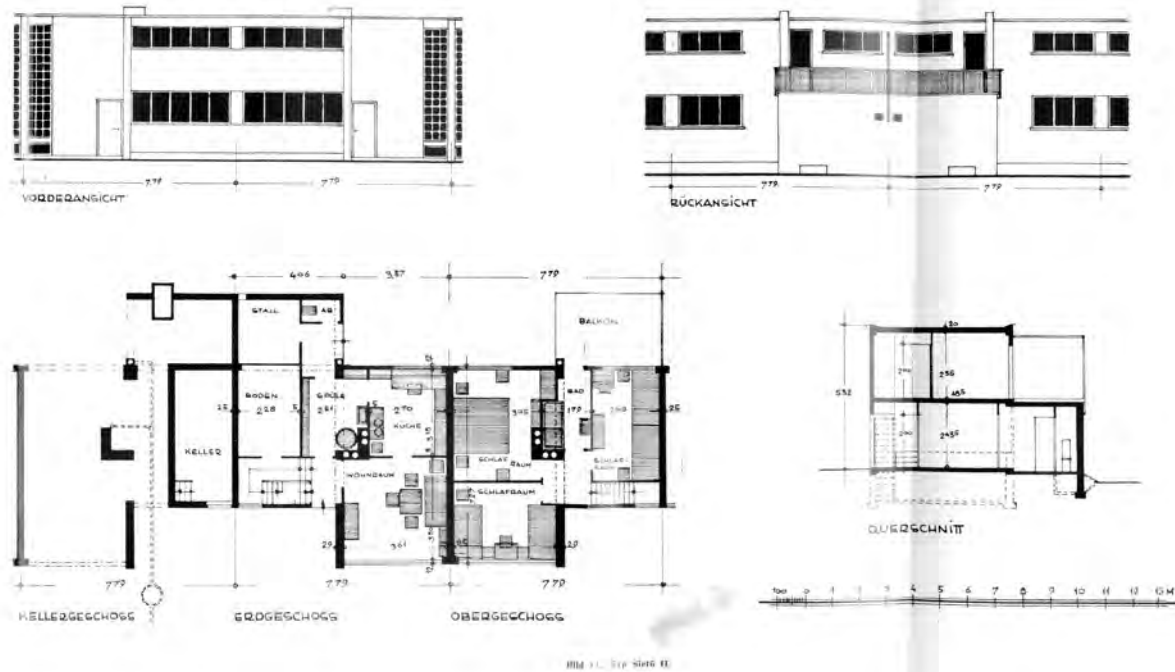


Fig. 157. Walter Gropius. Plan, section and elevations of Type II used in Phases 2 and 3, Torten, 1927-29 and Type IIZ, constructed with standard brick, required by the RFG as a control group, after February 1928. Source: "Bericht Über Die Versuchssiedlung in Dessau." RFG Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).



Fig. 158. Walter Gropius. Photograph of a series of Type II's, under construction, with the new three hundred and sixty centimeter module clearly visible (top) and photograph of a pair of Type II's, with finishes, showing the expression of load-bearing structure (bottom), 1927-28.
Sources: HAM/B-RM BRGA.22.85; HAM/B-RM BRGA.22.33.

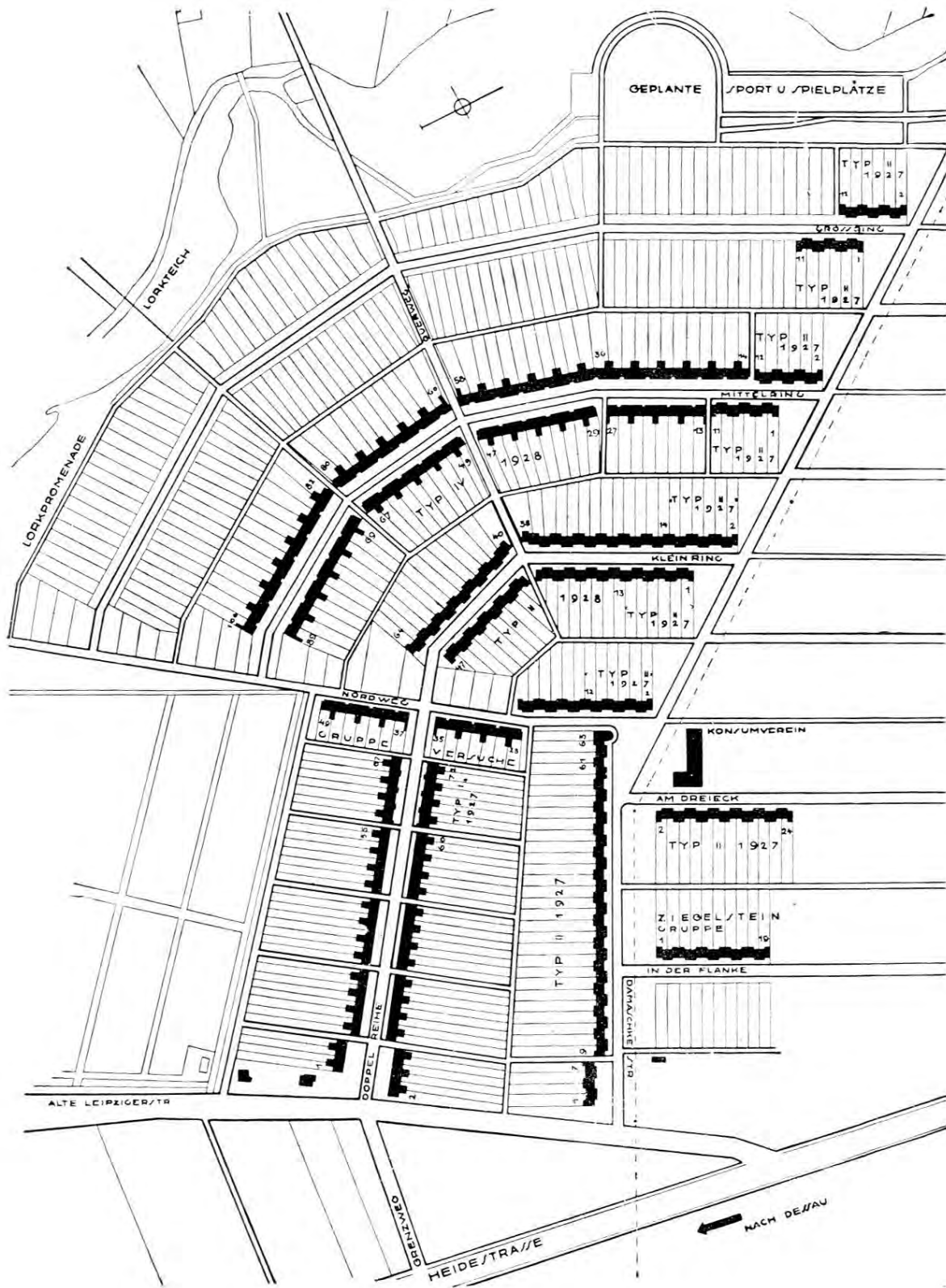


Fig. 159. Walter Gropius. Torten Settlement Plan, Final variant, April 1928.
 Source: "Bericht Über Die Versuchssiedlung in Dessau." RFG Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).

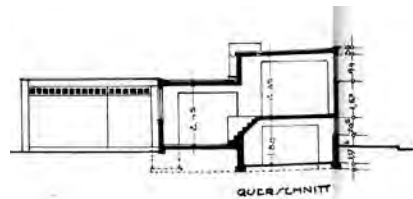
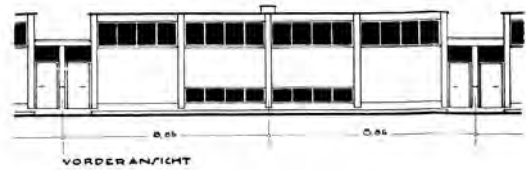
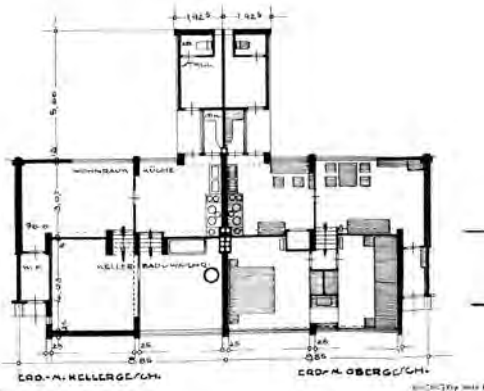
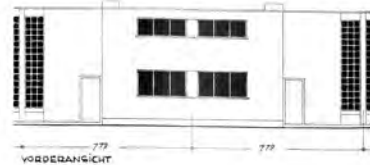
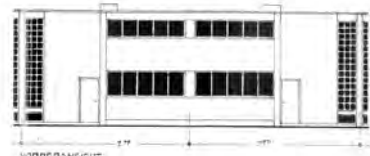
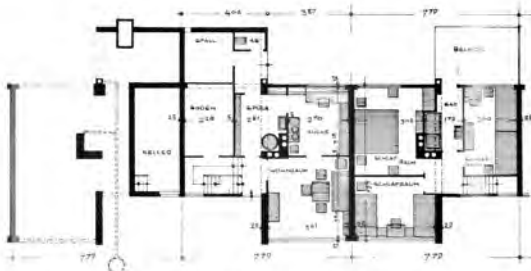
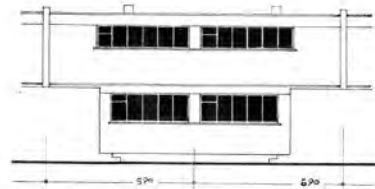
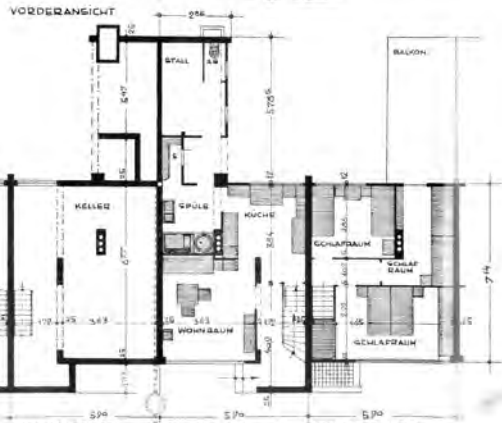
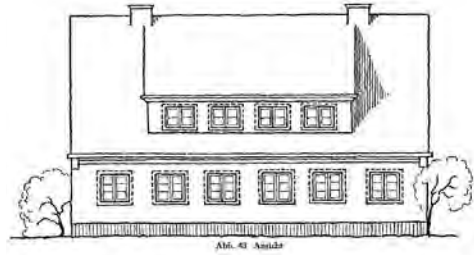
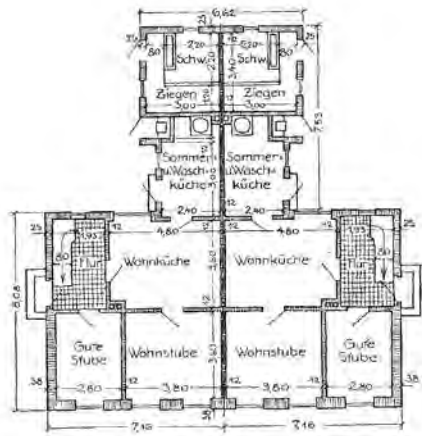


Fig. 160. Evolution of unit plans and elevations showing Hausform 4, Type I, Type II (and elevation of Type IIz), and Type IV, including section.
 Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).



Fig. 161. Photographs showing allotment garden view of Type II and street and allotment garden views of Type IV, Torten, 1929.

Source: HAM/B-RM BRGA.22.100; HAM/B-RM BRGA.22.36; HAM/B-RM BRGA.22.87.

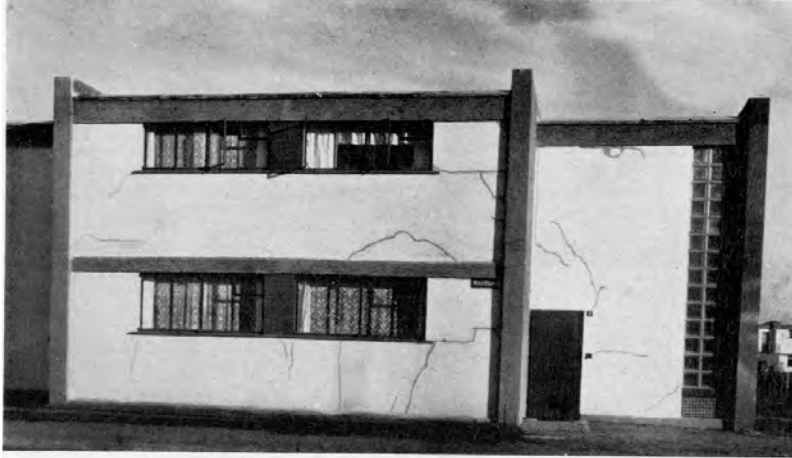


Bild 31. Rissebildung in den Zellenbetonfüllwänden Typ Sietö II, Bauabschnitt 1927.



Fig. 162. Photographs showing cracking in Type II facades, due to the use of large format pumice panels, which had not adequately cured, before being installed, in 1928 (top) and photographs of experimental Type IV units with smaller pumice panels in 1929 (middle, bottom).
Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).

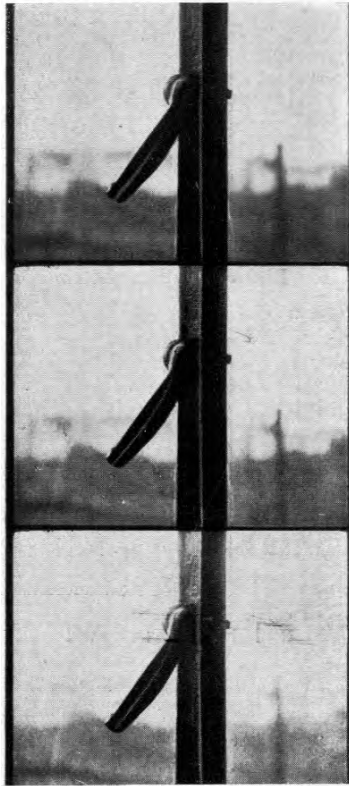


Bild 63.

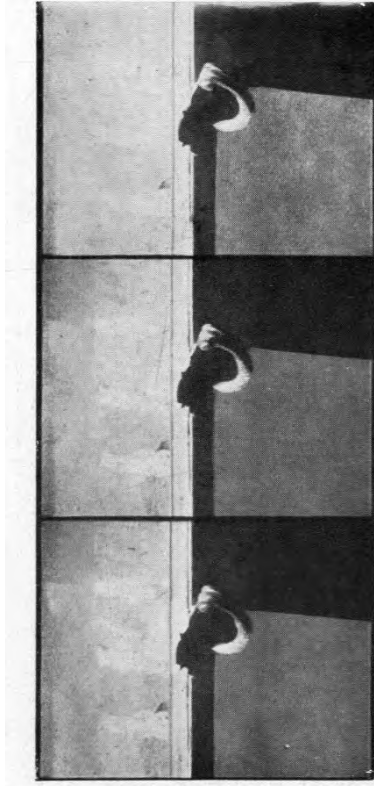


Bild 64. Griff. Fenster geschlossen.

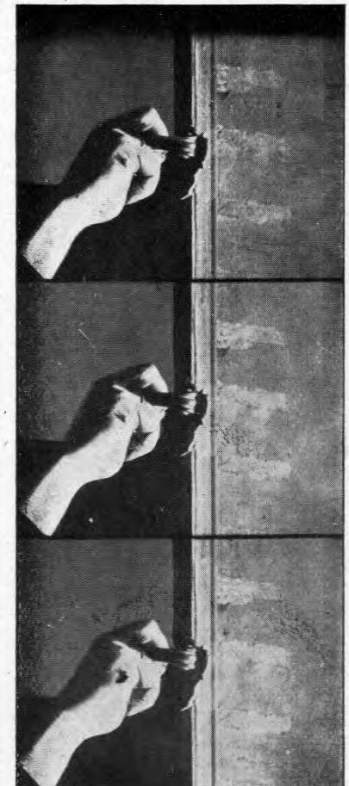


Bild 65.



Bild 66. Fensterstellung auf Kleinlüftung.



Bild 67. Reinigen des Fensters.



Bild 68. Ausstellband und Flügelfeststeller.

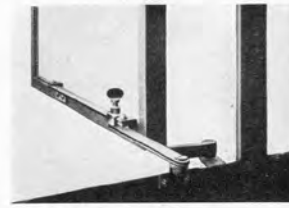


Bild 69.



Bild 70. Drehflügel und Flügelfeststeller.

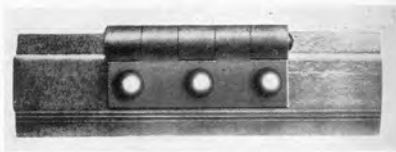


Bild 71. Bronzeband.

Fig. 163. Micromotion studies of window hardware at Torten, 1928.
 Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).

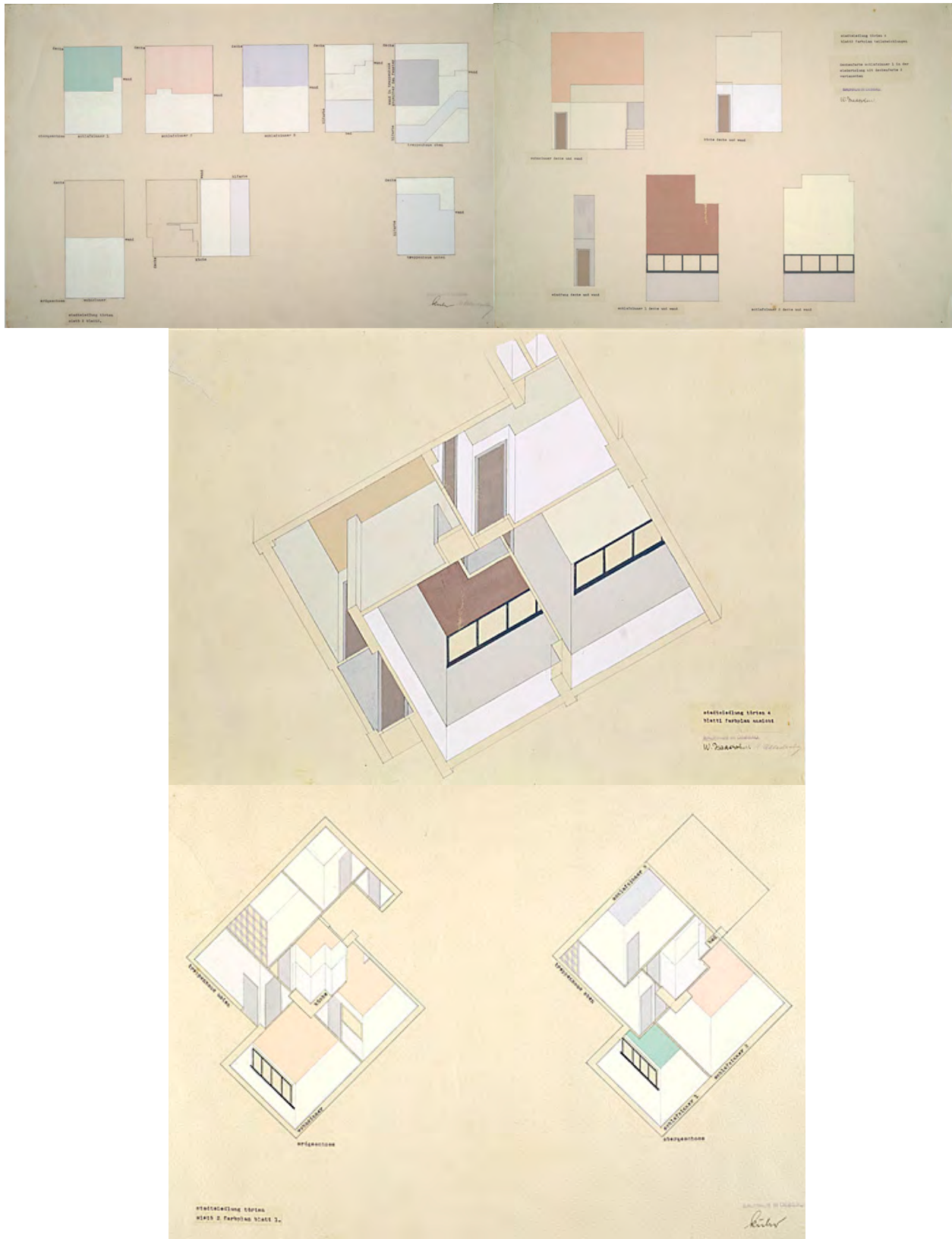
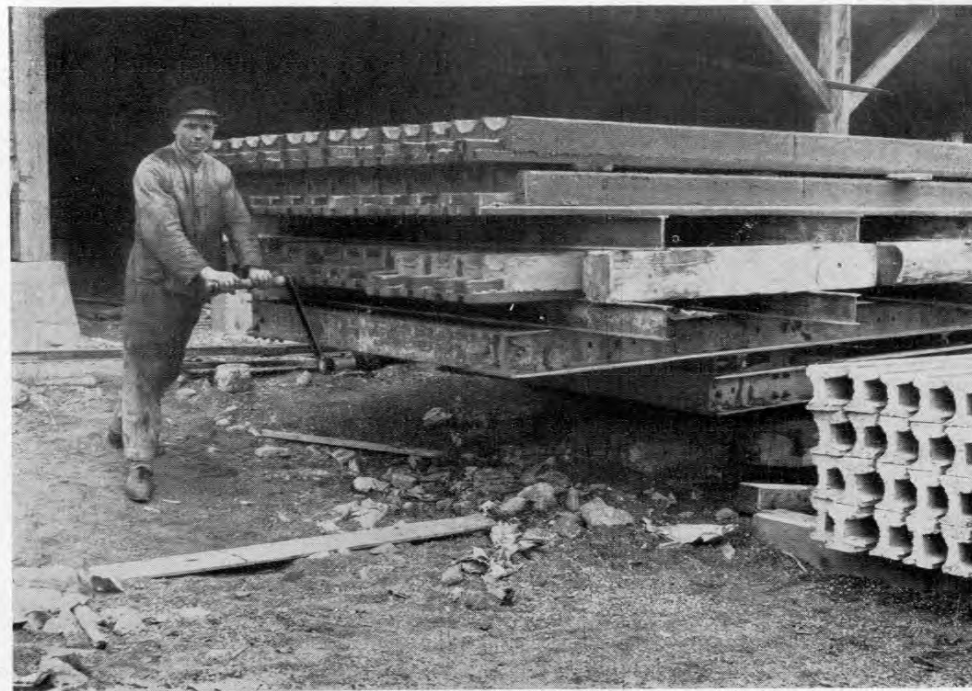
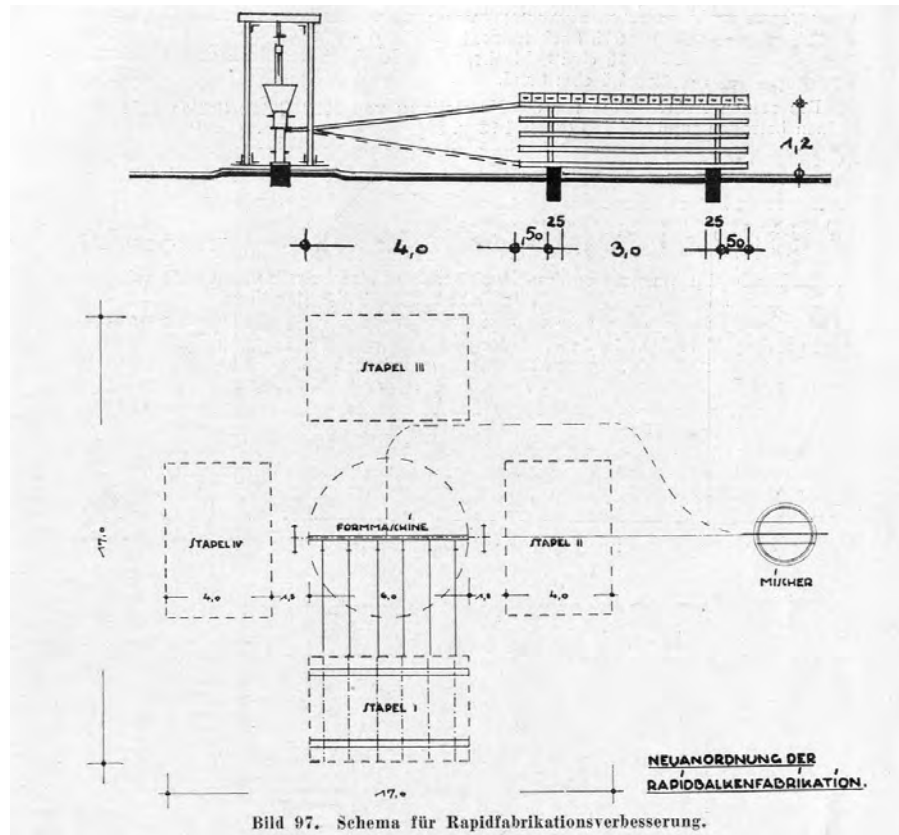


Fig. 164. Unfolded elevations (top) and isometric studies for the interior paint scheme of Type IV (middle) and isometric study of interior paint scheme for Type II (bottom), 1928.
 Source: HAM/B-RM BRGA.22.4; HAM/B-RM BRGA.22.5; HAM/B-RM BRGA.22.6; HAM/B-RM BRGA.22.3



**Bild 96. Verbesserte Rapidbalkenfabrikation.
Verfahrbare Bühnentische.**






Fig. 165. Drawing and photograph of rapid beam casting and curing equipment, standardized through work at Torten, between 1926 and 1929.





Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).

ORGANISATIONSPLAN M. 1:1000

Stand der Disposition
am 25. 6. 1928

Stadtsiedlung Dessau-Törten
Reichsheimstätten 3. Baujahr 1928

-  Baujahr 1926-1927
-  1. Bauabschnitt 1928
-  2. "
-  3. "
-  4. "

-  Zufuhr der Rohstoffe
-  Krähngleis
-  Feldbahngleis
-  Kalkgleis

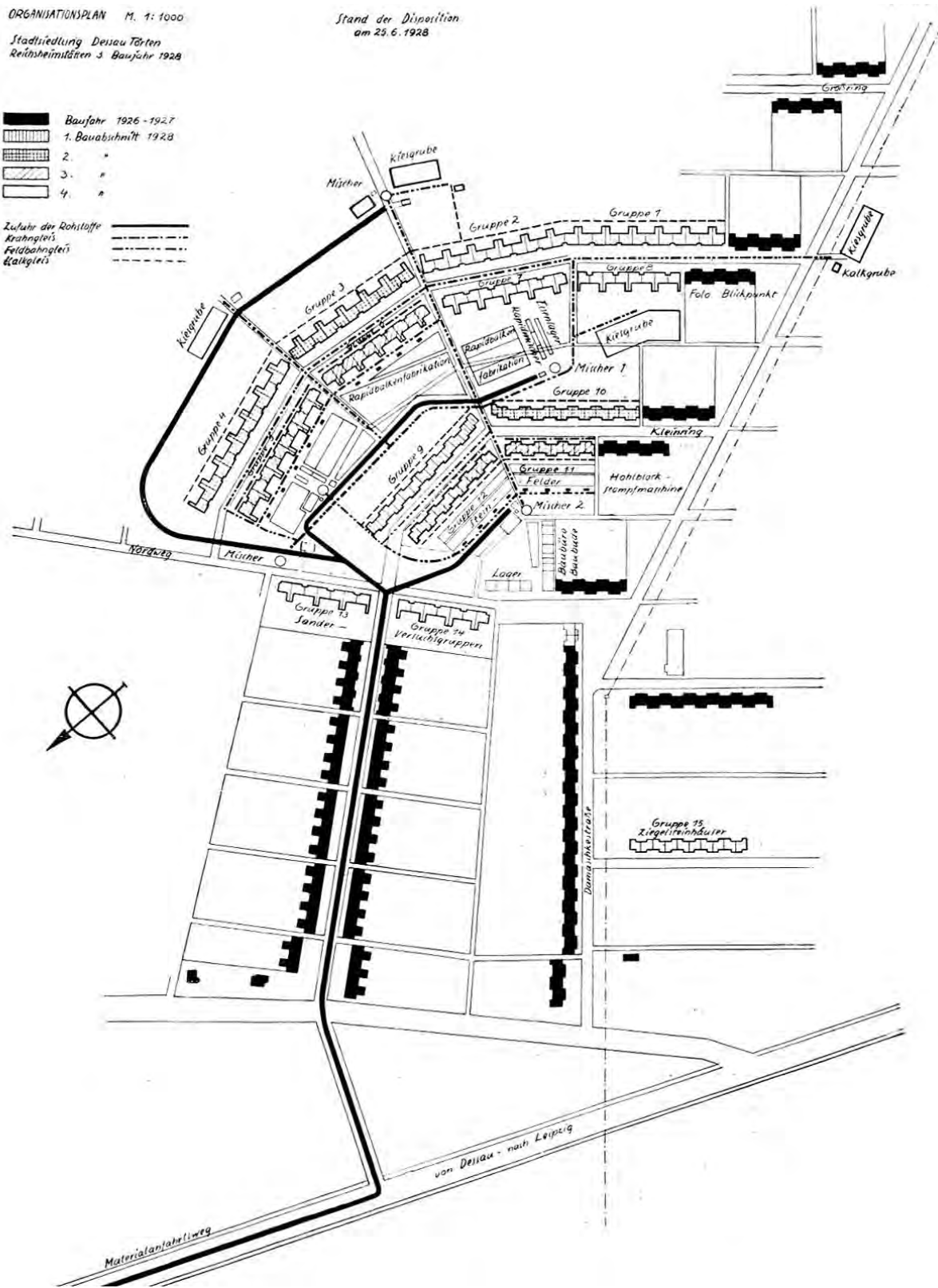


Fig. 166. W. Gropius. Organizational Plan (Construction Plant Plan) of Törten, Phase III, showing positions of materials and equipment as well as planned routes of distribution, on June 26, 1928.
Source: "Bericht Über Die Versuchssiedlung in Dessau." RFG Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).

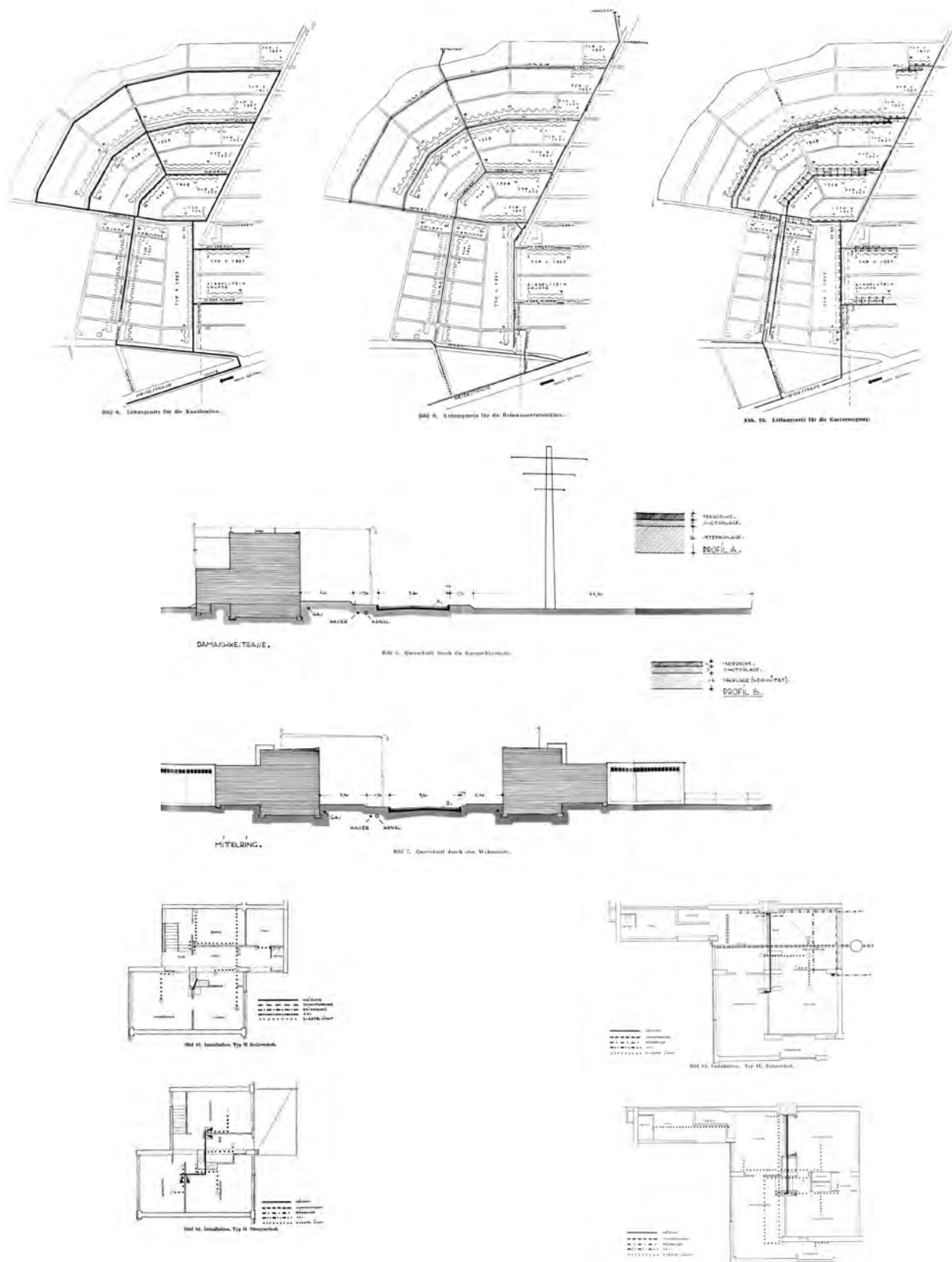


Fig. 167. W. Gropius. Plans of canalization, rainwater run off and gas lines (top), street sections, showing infrastructure (middle), and unit plans of Type II and Type IV showing infrastructure (bottom).
 Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).



Bild 119. Zeitreihe für Gruppe S. (Die Schnürbünde sind gesteckt.)
Stand der Arbeit am 2. 7. 1928.



Bild 120. Zeitreihe für Gruppe S (Aussehachtung).
Stand der Arbeit am 7. 7. 1928.



Bild 121. Zeitreihe der Gruppe S (Fundamente).
Stand der Arbeit am 9. 7. 1928.



Bild 123. Zeitreihe der Gruppe S (Kellermanerwerk).
Stand der Arbeit am 14. 7. 1928.

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
REICHHEIMTATEN																											
WIEDLUNG																											
DE/BAU																											
TOOTEN																											
STAND DER ARBEITEN AM 7. 7. 1928																											
GRUPPE	1																										
	2																										
	3																										
	4																										
	5																										
	6																										
	7																										
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	10																										
	11																										
	12																										
	13																										
	14																										
	15																										

Fig. 170. W. Gropius. Progress photos showing masonry strings for cement blocks being placed, July 2, 1928, excavation, July 7, 1928, foundation construction, July 7, 1928, and cellars being constructed, July 14, 1928, as well as a progress chart, used by the contractor (right), used to manage and record the construction of Group 8 Type IV.
Source: "Bericht Über Die Versuchssiedlung in Dessau." RFG Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).



Bild 120. Zeitreihe der Gruppe 8 (Beginn des Verlegens der Kellergehölbdecke).
Stand der Arbeit am 13. 7. 1928.



Bild 121. Zeitreihe der Gruppe 8.
Stand der Arbeit am 15. 7. 1928.



Bild 125. Zeitreihe der Gruppe 8 (Erdgeschoßmauerwerk).
Stand der Arbeit am 16. 7. 1928.



Bild 122. Zeitreihe der Gruppe 8 (Fundamente Kellermauerwerk).
Stand der Arbeit am 18. 7. 1928.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
BEKRIEHLICHKEITEN																															
LEBENS- UND ARBEITS- BEDINGUNGEN																															
STAND DER ARBEITEN																															
AM 14. 7. 1928																															
GRUPPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

Fig. 171. W. Gropius. Progress photos showing the cellar ceiling being installed, July 14, 1928, first level masonry walls being constructed, July 15 and July 16, 1928, foundation of cellar (missdated, out of sequence) as well as a progress chart, used by the contractor (right), used to manage and record the construction of Group 8 Type IV.
Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).



Bild 127. Zeitreihe der Gruppe 8 (Erdgeschossecke).
Stand der Arbeit am 19. 7. 1928.



Bild 128. Zeitreihe der Gruppe 8 (Beginn der Obergeschossecke).
Stand der Arbeit am 21. 7. 1928.



Bild 129. Zeitreihe der Gruppe 8. Stand der Arbeit am 23. 7. 1928.



Bild 130. Zeitreihe der Gruppe 8 (Obergeschossecke fast fertig). Stand der Arbeit am 31. 7. 1928.

RECHT/HEIM/TÄTEN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
LEBUNG																															
DE/AU																															
TOTEN																															
/STAND DER ARBEITEN																															
AM 24. 7. 1928																															
GRUPPE 1																															
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Bild 127.

RECHT/HEIM/TÄTEN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
LEBUNG																															
DE/AU																															
TOTEN																															
/STAND DER ARBEITEN																															
AM 28. 7. 1928																															
GRUPPE 1																															
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14																															
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Bild 128.

Fig. 172. W. Gropius. Progress photos showing deck for ground floor being installed, July 19 and July 21, 1928, upper floor walls being erected, July 23, 1928 and roof deck being installed July 31, 1928 as well as two progress charts, used by the contractor (right), used to manage and record the construction of Group 8 Type IV. Source: "Bericht Über Die Versuchssiedlung in Dessau." RFG Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).



Bild 131. Zeitreihe der Gruppe 8 (Anbringen der Gefällschicht und der Isolierung auf dem Dach).
Stand der Arbeit am 2. 8. 1928.



Bild 132. Zeitreihe der Gruppe 8 (Gefällschicht fertig, Montage der Liehtruleitung).
Stand der Arbeit am 4. 8. 1928.

116



Bild 133. Klempnerarbeiten. Vorhängerinne mit Verdeckstreifen.



Bild 134. Dachdeckung „Awexil“.

Fig. 173. W. Gropius. Progress photos showing roof insulation and membrane being installed, August 2, 1928, and various installations being installed, between August 4 and 10, 1928.

Source: "Bericht Über Die Versuchssiedlung in Dessau." *RFG Sonderheft* Nr. 7, no. Gruppe IV NR. 4 (April 1929).

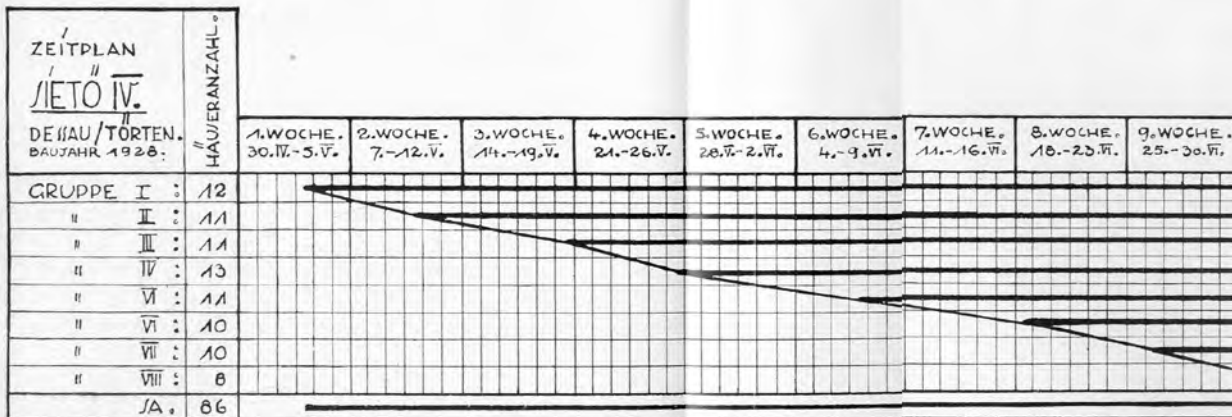
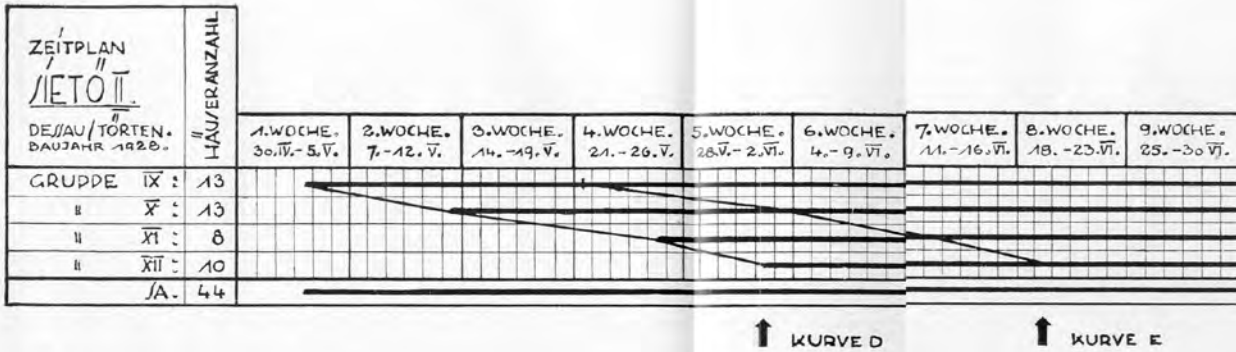
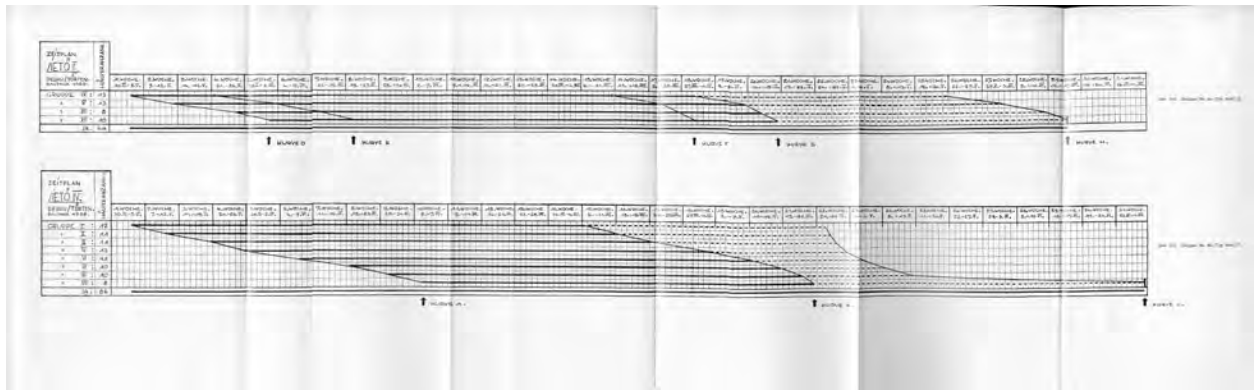


Fig. 174. W. Gropius. Zeitplan (Gantt chart) showing the spatial and temporal progress of work on the street with Type II's and the street with Type IV's between April and December, 1928.
Source: "Bericht Über Die Versuchssiedlung in Dessau." RFG Sonderheft Nr. 7, no. Gruppe IV NR. 4 (April 1929).

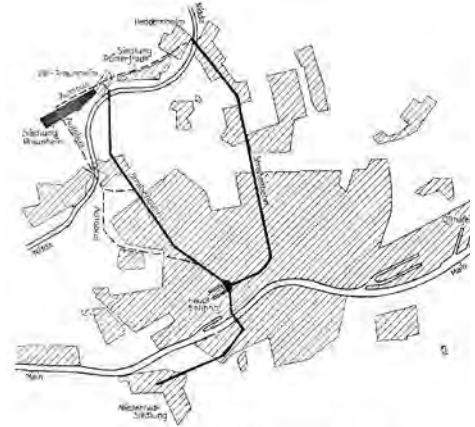
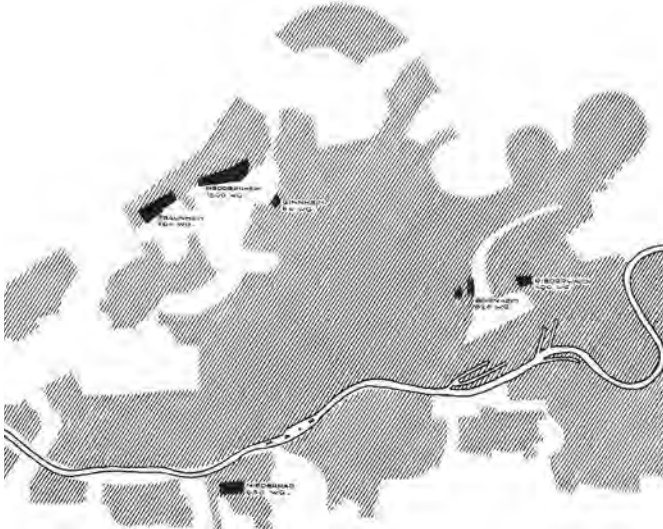


Bild 4.
Verbindung der Siedlung Praunheim zur Stadt Frankfurt a. M.
Am Oberrhein liegt die neue Platzanlage.

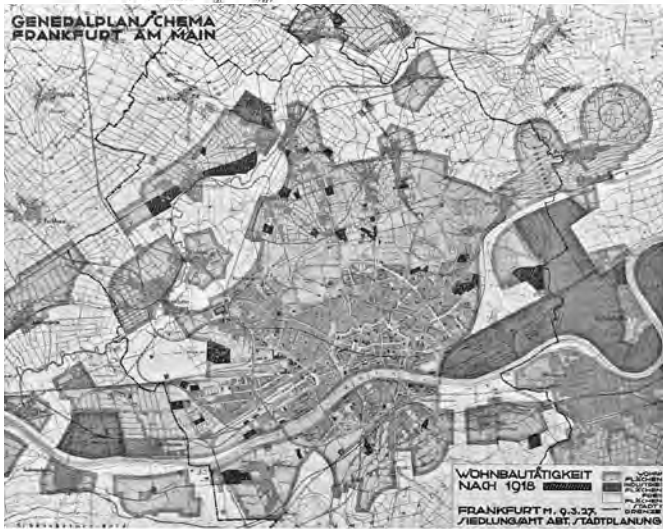
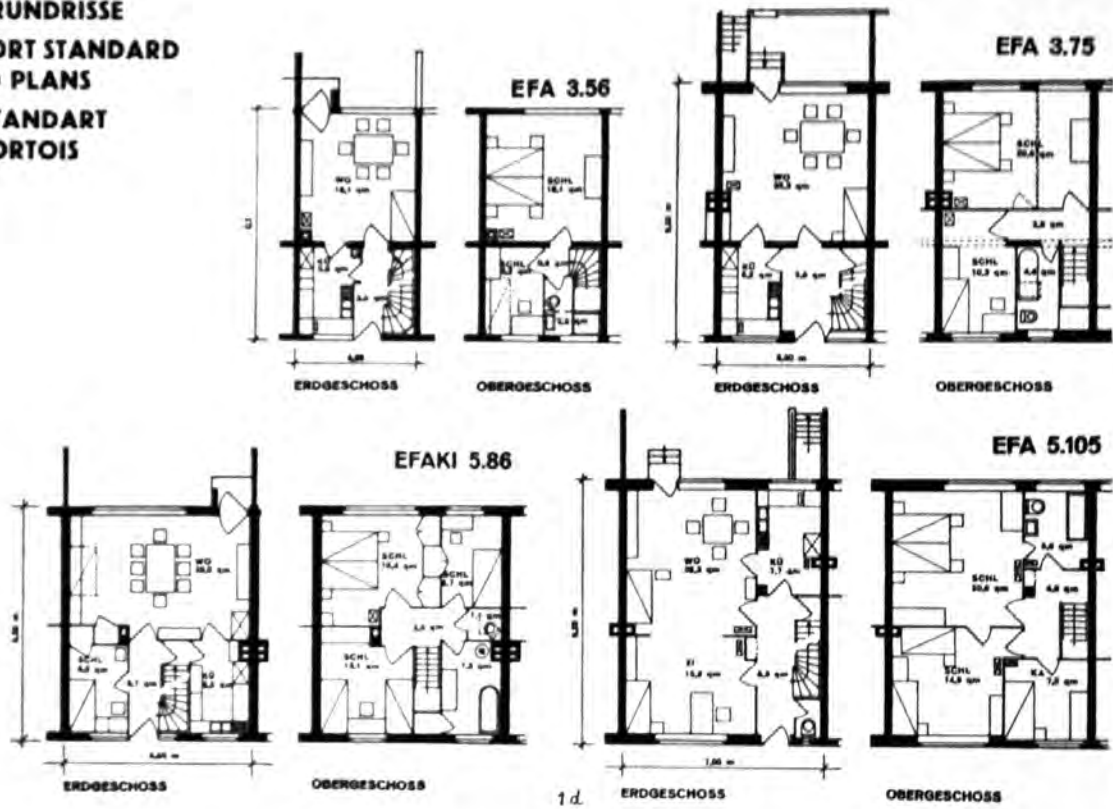


Fig. 176. Plates showing New Frankfurt settlements: First phase of settlements, including Praunheim Phase I, 1926 (top right), transportation link to Praunheim (top right), General plan scheme of New Frankfurt, March 9, 1927, Praunheim, Phase I and II, top left settlement (middle left), General plan scheme of New Frankfurt, August 1928, Praunheim, Phase I, II and II and Mammelsheimerstrasse, labeled in red (middle right), General plan scheme for land use, Frankfurt, with Westhausen visible, below new cemetery (bottom).
Sources: *Das Neue Frankfurt* 5 (May 1926-27). 95; "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen Sonderheft Nr. 4*, no. Gruppe IV, NR. 1 (April 1929). 10; *Das Neue Frankfurt* 8 (August 1928). 115; *Ibid.* 125; *Das Neue Frankfurt* 3 (March 1930). 30.

**FRANKFURTER
TYPENGRUNDRISSSE
FRANKFORT STANDARD
GROUND PLANS
PLANS-STANDART
FRANCFORTOIS**



36

ERKLÄRUNG DER BEZEICHNUNGEN:
EXPLANATION OF ABBREVIATIONS:
EXPLICATION DES ABBRÉVIATIONS:

Efa = Einfamilienhaus · One-family house · Maison pour une famille

Efaki = Einfamilienhaus für Kinderreiche · One family house for a large family · Maison pour une famille nombreuse

Efaelite = Einfamilienhaus mit Einliegerwohnung und Dachterrasse · One-family house with lodgers' rooms and rooftop terrace · Maison pour une famille avec pièces pour des souslocataires et toit à terrasse

Die erste Ziffer bedeutet Anzahl der Zimmer, die zweite Ziffer Wohnfläche in qm

The first figure refers to the number of rooms, the second to habitable surface in sq. m.

Le premier chiffre désigne le nombre des pièces, le second la surface habitable en mètres carrés

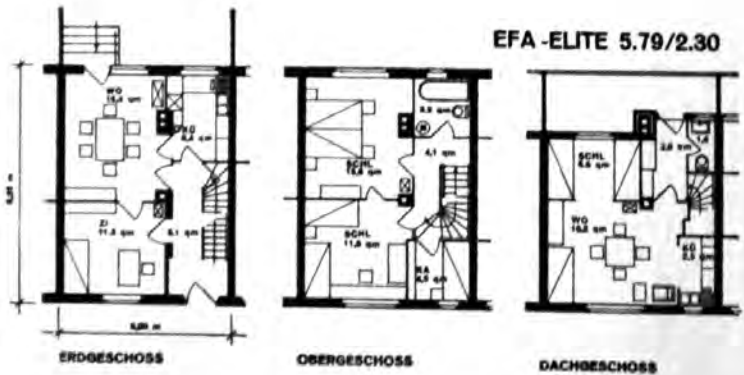


Fig. 177. Frankfurt Municipal Building Office. Frankfurt Standard Ground Plans, 1929.

Source: May, Ernst. "Housing Policy of Frankfurt." *Das Neue Frankfurt* Special Edition (January 12, 1929).

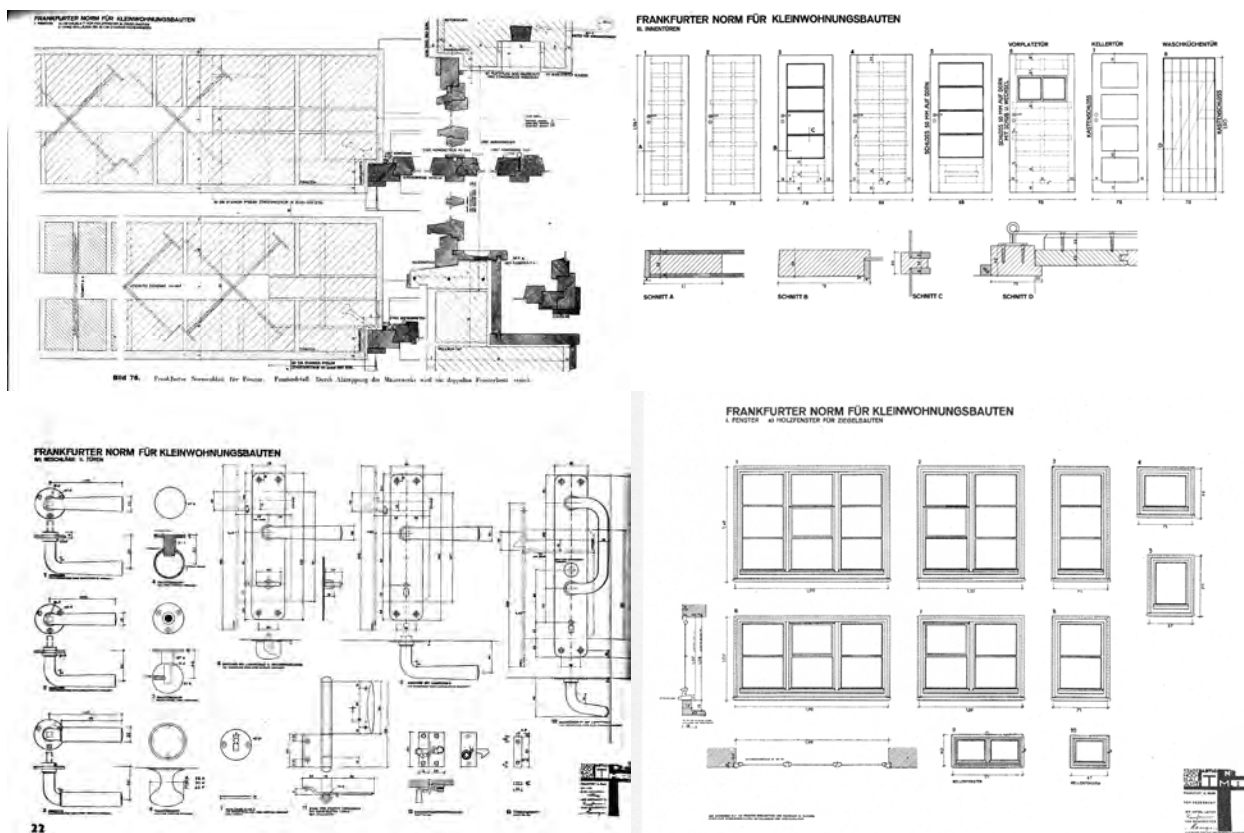


Fig. 179. Frankfurt Municipal Building Office. Frankfurt Standards for Window detail (top left), Door (top right), Door handle (bottom left) and Window openings for brick construction (bottom right) as well as two examples of the Frankfurter Register, showing chairs (bottom left) and a phone (bottom right). Sources: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 76; *ibid.* 77; *Das Neue Frankfurt* 3 (March 1930). 42; *Das Neue Frankfurt* 5 (May 1926-27). 100.



Fig. 180. Plate from DNF showing Frankfurt Norm gardens at Rommerstadt Siedlung, 1930.
Source: *Das Neue Frankfurt* 3 (March 1930). 79.

Lageplan der deutschen Bauhütten und Bauhüttenbetriebsverbände.

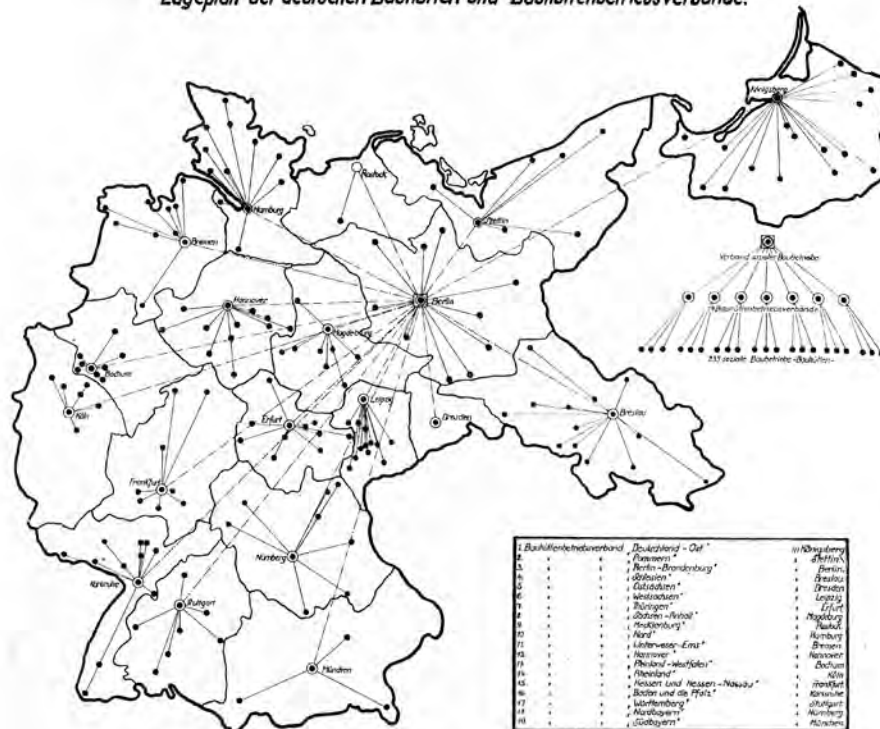


Fig. 181. Distribution map of German Bauhütten and (organizational chart) of the Bauhütten Contractors Association.
Source: Wagner, Martin. "Das Bauhüttensystem." *Soziale Bauwirtschaft* 3, no. 10/11 (20 May 1923): 119-21.

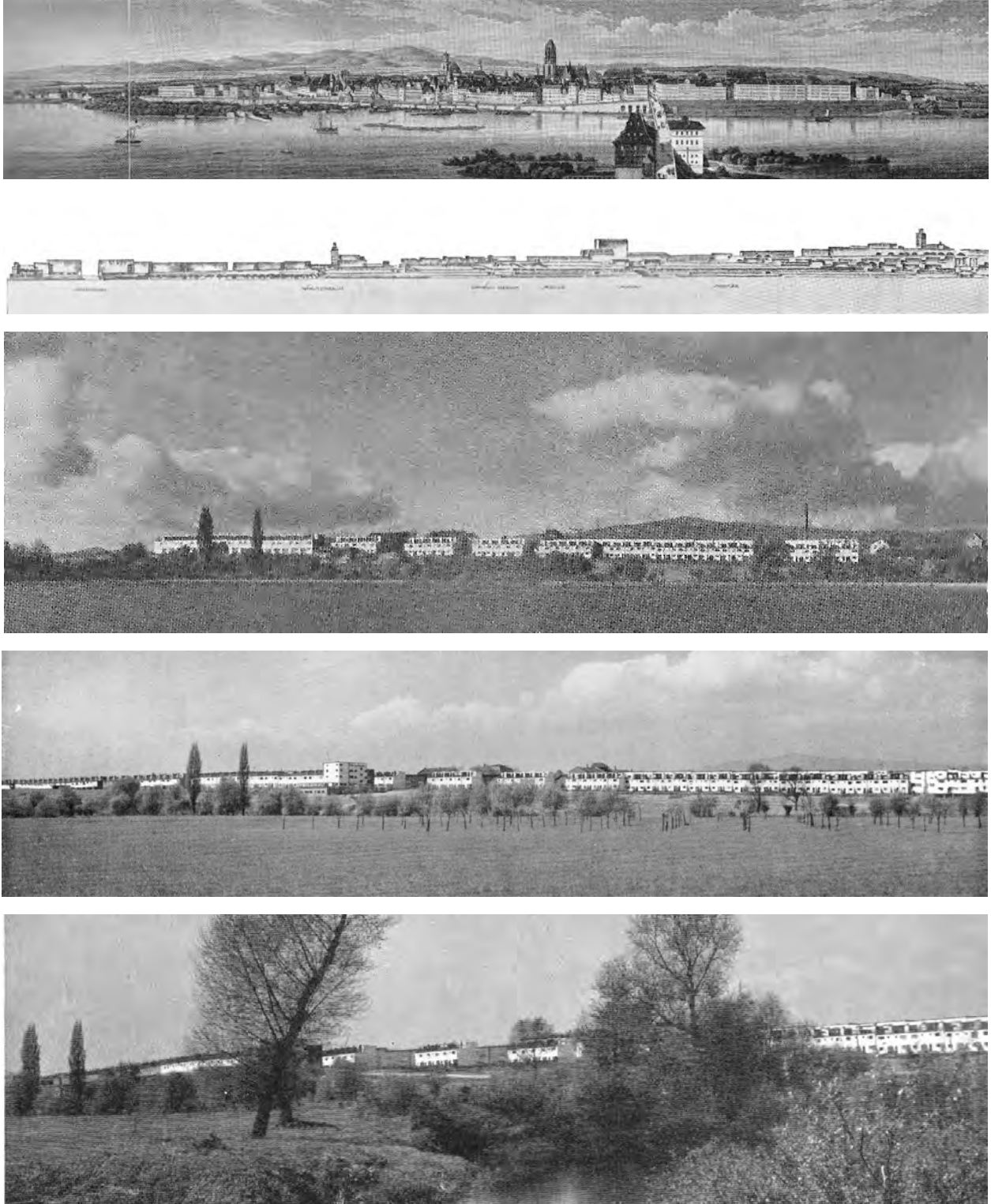
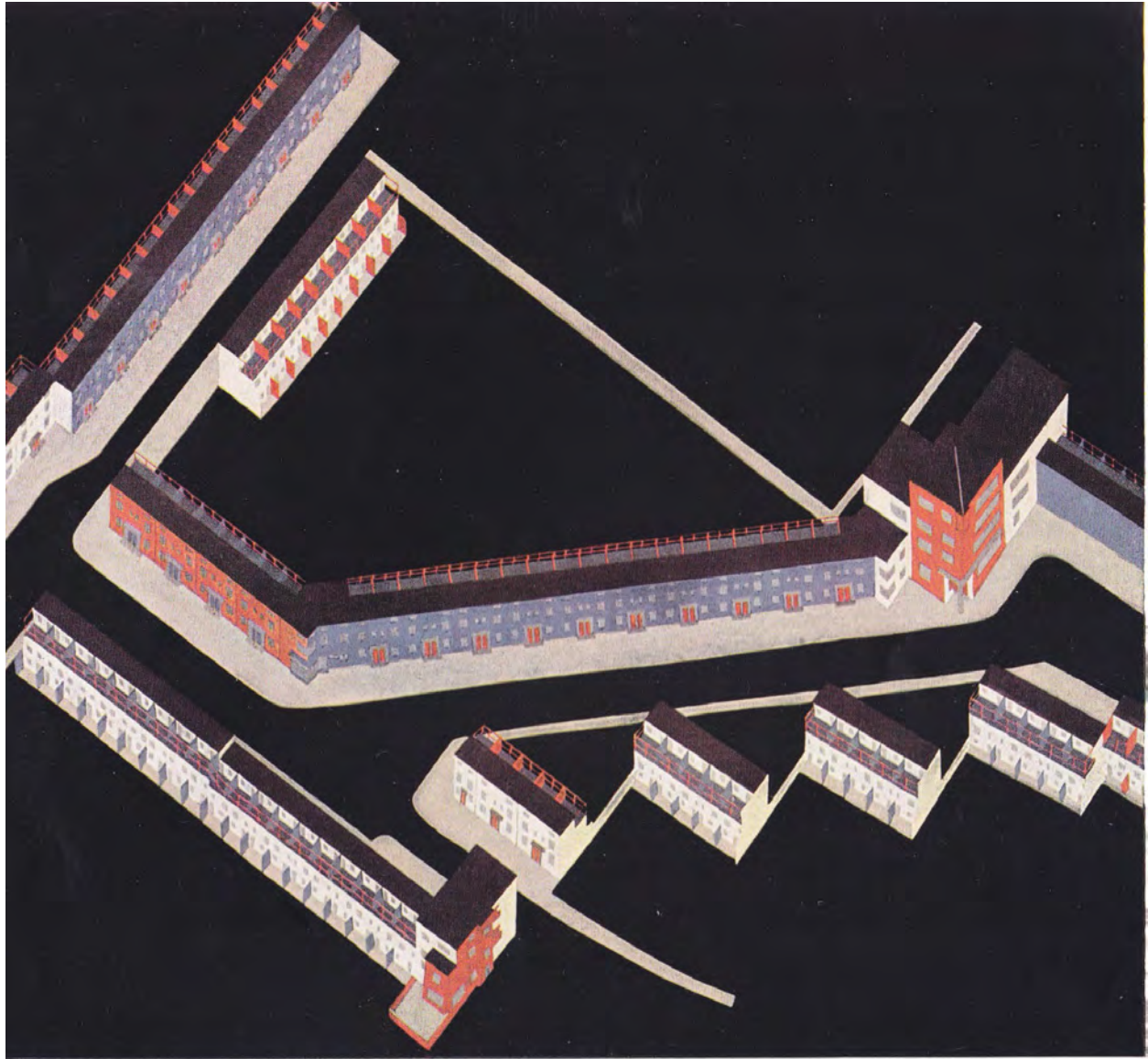


Fig. 182. Plates from *Das Neue Frankfurt* showing early 19th century panorama of the city, from the Main River (top), a panoramic study of the Bornheimer Hanges settlements, from the Main River, a panoramic photograph of Praunheim Phase I, late 1926, and two panoramic photographs of Praunheim Phase I and II, in 1928. Sources: *Das Neue Frankfurt* 5 (May 1927). 113; Ibid. 112; *Das Neue Frankfurt* 1 (October 1926). 22; *Das Neue Frankfurt* 8 (August 1928). 127; Ibid. 131.



NG PRAUNHEIM AUSSCHNITT

**Arch.: Stadtbaurat May, Mitarb.: Baurat Kaufmann
Farb.Tafel: Leistikow**

Fig. 183. Plate from *Das Neue Frankfurt* showing isometric study of color scheme for Praunheim Phase I, following research of the old city center.
Source: *Das Neue Frankfurt* 8 (August 1928). 112.

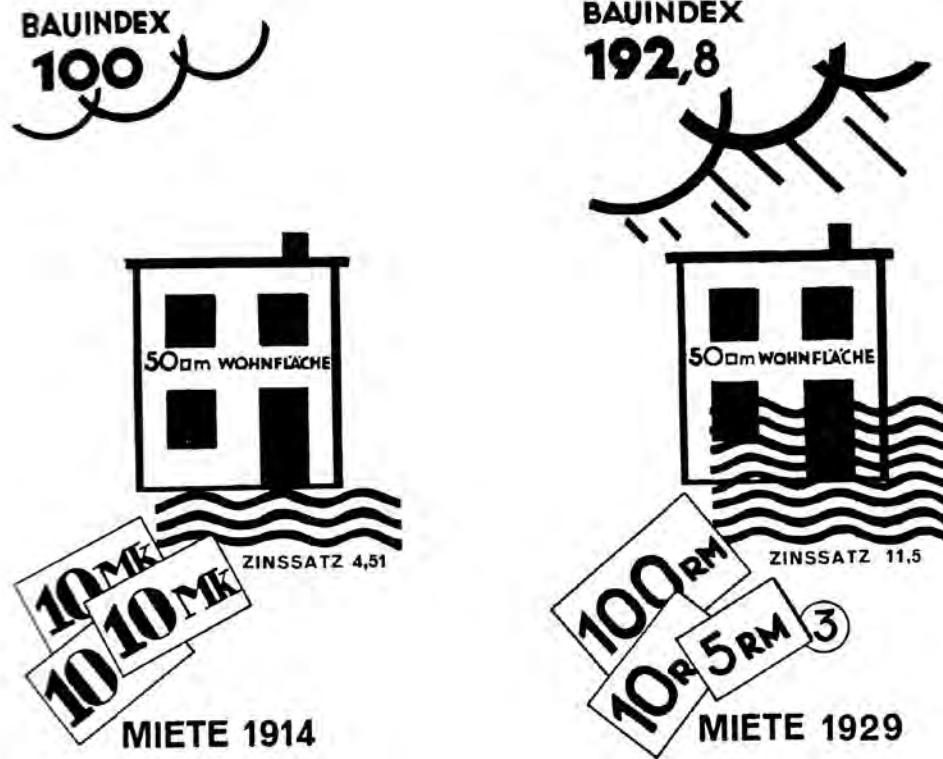


Fig. 184. Plate from *Das Neue Frankfurt* showing the construction index of 100 in 1914 and 192.8 in 1929. Source: *Das Neue Frankfurt* 3 (March 1930). 24.

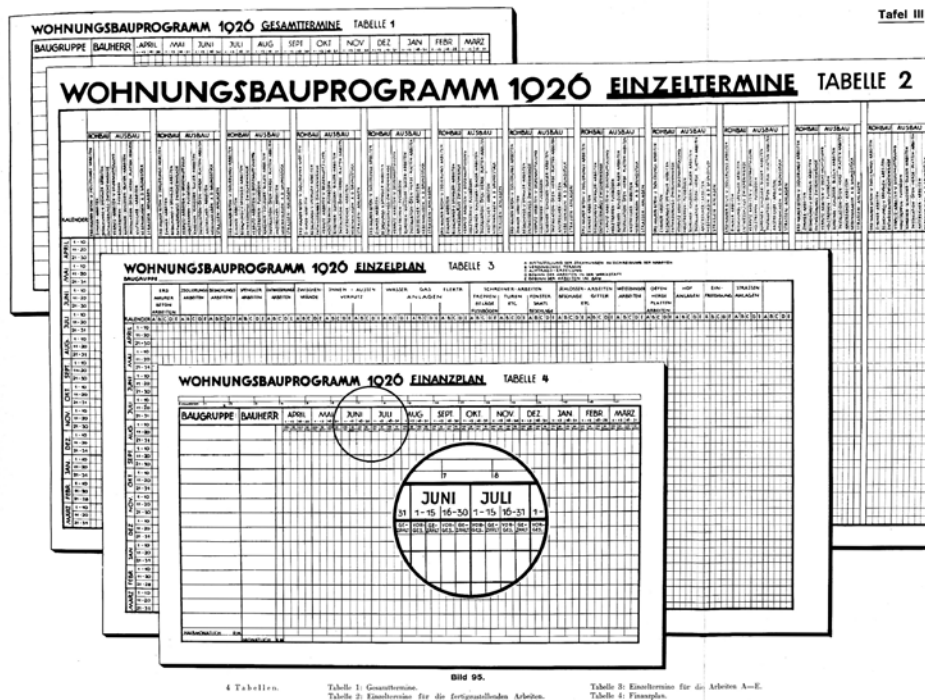
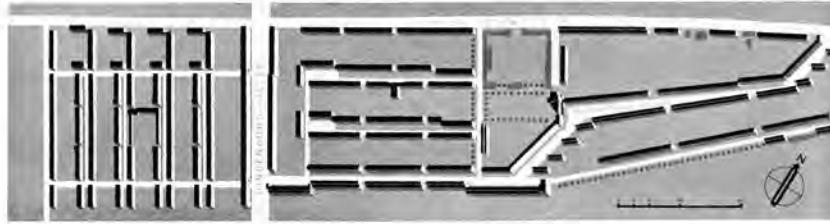


Fig. 185. Frankfurt Municipal Building Office. Sample instruction cards and gantt charts used during work on New Frankfurt.

Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 95.



2 SIEDLUNG PRAUNHEIM

Anzahl der Wohnungen: 1441

Bauherr: Die Stadt

Gelamplan: E. May, Mitarbeiter H. Boehm und Bangerl

Architektonische Bearbeitung: E. May, Mitarbeiter E. Kaufmann

Insgeamt	ZAHL DER WOHNUNGEN					Zubehör je Wohnung	Durchschnittswerte bei den Haupttypen für eine Wohnung				Zentralanlagen und sonst. Einrichtungen zur Erleichterung d. Haushaltsführung
	mit Raumzahl	1	2	3	4		Wohnfläche qm	Reine Baukosten RM	Gesamtkosten mit Grundstücksaufschlagung RM	Monatliche Miete RM	
I. Ausbau Bauzeit: 1.5.26 - 1.1.27 Bauindex: 1.654	173	1	2	6							Frankfurter Küche
						Küche	68	11800	14900	67.—	
II. Ausbau Bauzeit: 1.7.27 - 1.4.28. Bauindex: 1.714	565	123									Frankfurter Küche Zentralwalchküche
						Küche Bad Garten	75 76	5700 13500	6800 17100	30.— 64. bis 77.	
						Küche Bad Dachterrasse Garten	91	13500	20900	102.—	Frankfurter Küche Zentralheizung

Insgeamt	ZAHL DER WOHNUNGEN					Zubehör je Wohnung	Durchschnittswerte bei den Haupttypen für eine Wohnung				Zentralanlagen und sonst. Einrichtungen zur Erleichterung d. Haushaltsführung
	mit Raumzahl	1	2	3	4		Wohnfläche qm	Reine Baukosten RM	Gesamtkosten mit Grundstücksaufschlagung RM	Monatliche Miete RM	
III. Ausbau Bauzeit: 1.8.28 - 1.1.30 Bauindex: 1.899	703	3									Frankfurter Küche Zentralheizung Zentral-Wärme- wasserbereitung Zentralwalchküche
						Küche Braufbad Erde- schol- weg mit Garten	27,30 41,40 50,65 55,70	5600 8400 10260 11300	6750 10220 12500 13750	34,80 52,75 64,50 71,10	
						Küche Sitzbad Garten	54,50 55,35	11060 11230	14060 14280	72,65 73,75	
						Küche Bad Garten	75,50 76	16350 16430	19480 19550	100.— 101.—	Frankfurter Küche
						Küche Bad Garten	87	17700	22400	110,60	

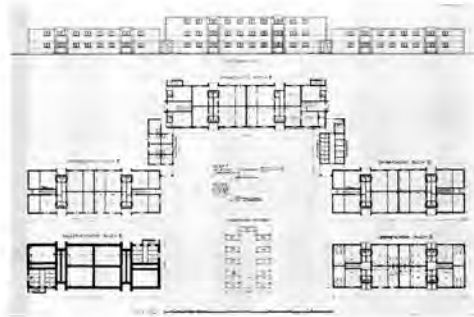
Sämtliche Einfam.-Häuser sind Reichsheimstätten

* Plattenbauten

** Wohnungen für kinderreiche Familien. Mieten durch Zuschüsse verbilligt

Keine Baukostenzuschüsse

Fig. 186. Plate from *Das Neue Frankfurt* showing Praunheim Settlement plan and unit chart.
Source: *Das Neue Frankfurt* 3 (March 1930). 60.

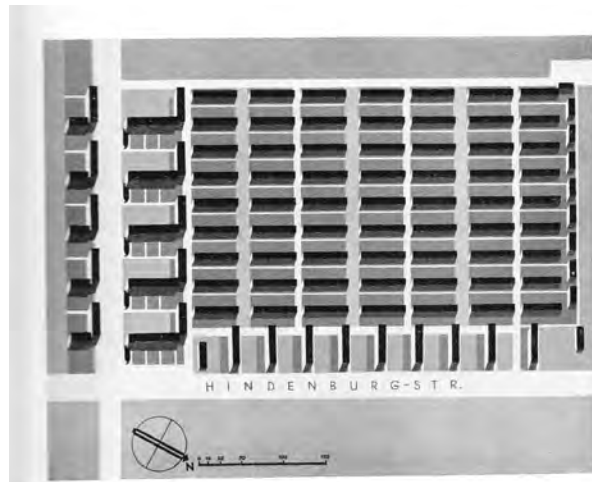


GRUNDRISS, LAGEPLANSKIZZE UND ANSICHT DES KOPFBAUES

SIEDLUNG MAMMOLSHAINERSTRASSE

BAUHERR: DIE STADT

ZAHL DER WOHNUNGEN						Durchschnittswerte bei den Haupttypen für eine Wohnung				Einrichtungen z. Erleichterung d. Haushaltsführ- und Zentralanlagen	
Insgesamt	mit Raumzahl					Zubehör je Wohnung	Wohnfläche qm	Reine Baukosten RM	Gesamtkost. in Aufschlagsleistung RM		Monatliche Mietleistung RM
	1	2	3	4	5	6					
296		296					32	3600	4700	20.-	Zentralgelegene Warm- und Brausebäder



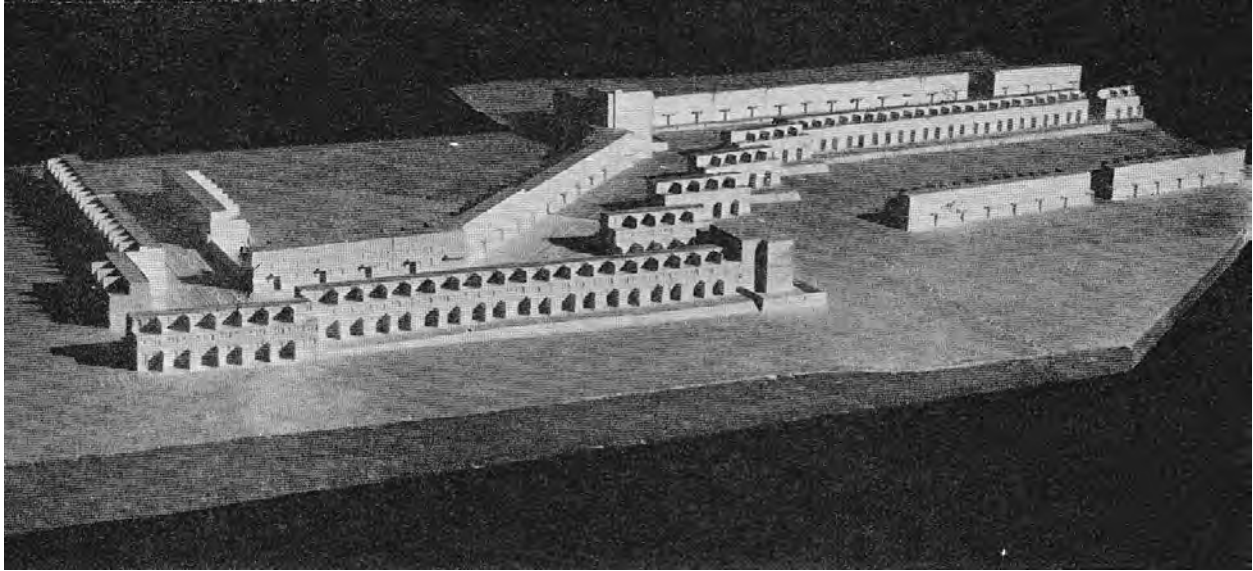
1 SIEDLUNG WESTHAUSEN

Anzahl der Wohnungen: 1532
 Bauherr: Gartenstadt A. G. und National Heimstätte
 Gesamtplan: E. May, Mitarbeiter H. Bock und Bangert
 Architektonische Bearbeitung: E. May, E. Krausmann, F. Kramer, Blanck, sowie die Privatarchitekten O. Fucker, F. Schuller.

ZAHL DER WOHNUNGEN						Durchschnittswerte bei den Haupttypen für eine Wohnung				Zentralanlagen und sonst. Einrichtungen zur Erleichterung d. Haushaltsführung	
Insgesamt	mit Raumzahl					Zubehör je Wohnung	Wohnfläche qm	Reine Baukosten RM	Gesamtkost. in Aufschlagsleistung RM		Monatliche Mietleistung RM
	1	2	3	4	5						
I. Abschnitt 1928/30			210*			Küche Bad	41	7300	9700	Die monatlichen Mieten bleiben durchschnittlich unter 120 M je qm Wohnfläche	Frankfurter Küche
			216			Küche Stilzbad	47	7525	10100		Zentralheizung, Warmwasserföhr., Zentralwafchküche
II. Abschnitt 1930/31	1096		169*				41	7300	9700		Frankfurter Küche
			486				41	7300	9700		Frankfurter Küche
			180			Küche Bad	47	7600	10100		Zentralheizung, Warmwasserföhr., Zentralwafchküche
			130				45	8200	10000		
			40**				61	9700	13000		
		32**				57	10000	13400			Frankfurter Küche

* Plattenbauten
 ** Wohnungen für kinderreiche Familien, Mieten werden durch Zuschüsse verbilligt.
 † Keine Baukostenzuschüsse

Fig. 187. Plates from Das Neue Frankfurt showing Mammolshainerstrasse Settlement plan and unit chart (top) and Westhausen Settlement plan and unit chart (proposed) (bottom).
 Sources: *Das Neue Frankfurt* 8 (August 1928), 150; *Das Neue Frankfurt* 3 (March 1930), 56.



259.

**Lageplan der Siedlung Praunheim
I. Bauabschnitt Arch. E. May, Frank-
furt, Mitarbeiter: Baurat E. Kauf-
mann**

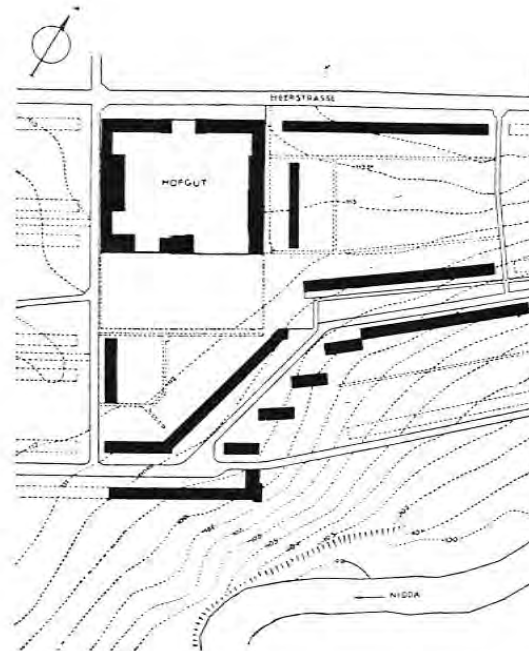


Fig. 188. Plate from *Das Neue Frankfurt* showing Praunheim Phase I model and plate from *Probleme des Bauens* showing Praunheim Phase I settlement plant.
Sources: *Das Neue Frankfurt* 5 (May 1927). 108; May, Ernst. "Volkswohnungsbau in Frankfurt A. M." In *Probleme Des Bauens*, edited by Fritz Block. Potsdam: Muller und Kiepenheuer (Bund Deutscher Architekten), 1928. 191.

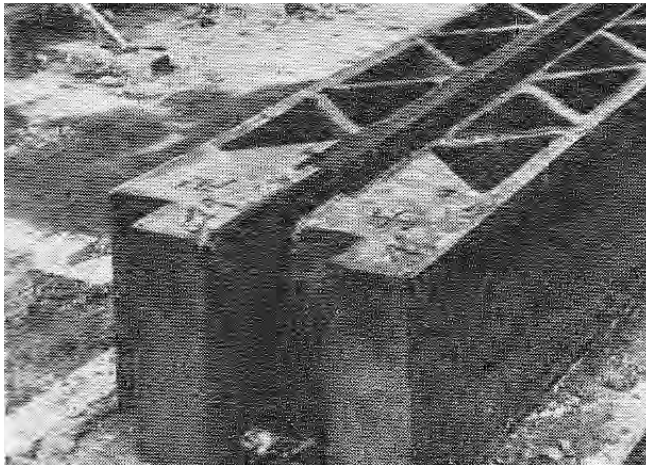
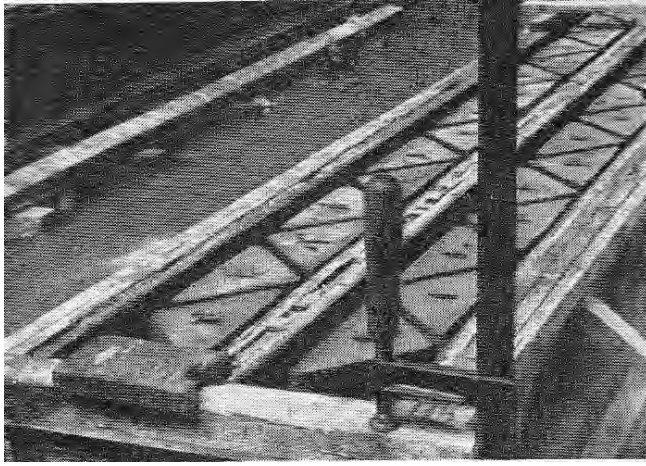


Fig. 80.—Molding of Visintini Girders. (See p. 155.)

Fig. 77.—View of Visintini Columns and Girders in Textile Machine Shop. (See p. 121.)

Fig. 189. Plates from *Das Neue Frankfurt* showing fabrication of Visintini beams at the Frankfurt Fair (top) and plates from *Reinforced Concrete in Factory Construction* showing fabrication and erection of Visintini beams in an American factory (bottom).

Sources: *Das Neue Frankfurt* 2 (December 1926). 37; Thompson, Sanford E. *Reinforced Concrete in Factory Construction*. New York: The Atlas Portland Cement Company, 1907. 149, 153.

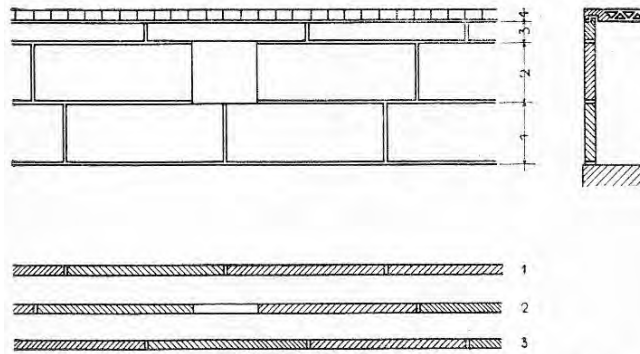
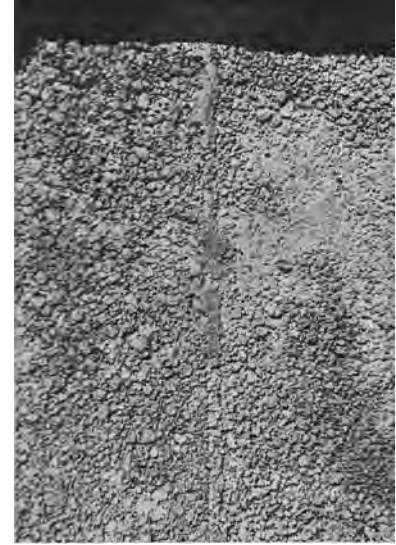
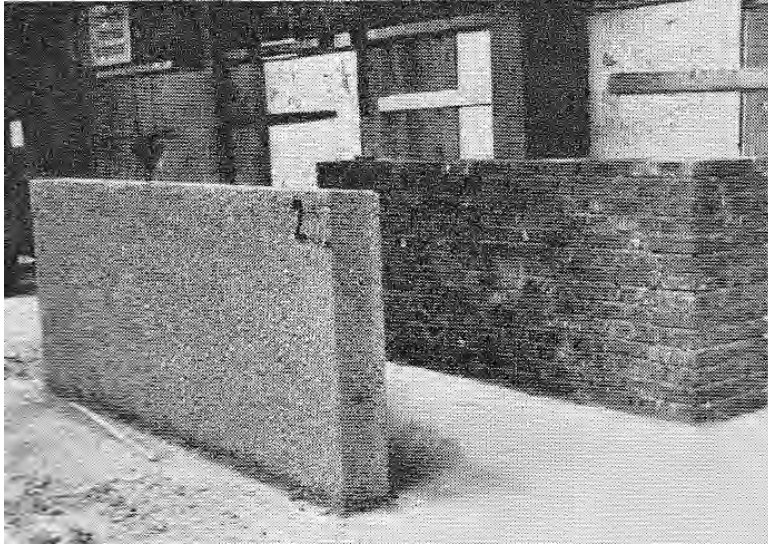


Bild 16: Schichtenaufbau der Gefchoffe

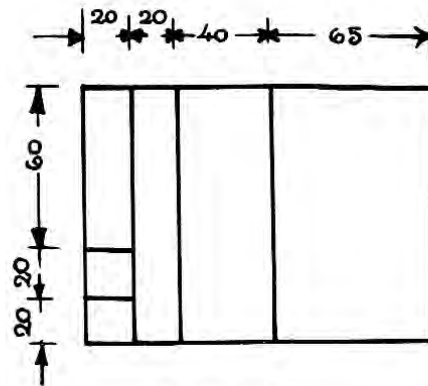


Bild 105.

Zerteilung einer Bimsbetonplatte in Wurfel, Saulen und Platten zur Untersuchung der Materialeigenschaften.

Fig. 190. Plates from *Das Neue Frankfurt* comparing a Frankfurt System panel and a standard brick wall, showing the texture of the pumice-based mixture (top), elevation, section and plan drawing showing three Frankfurt panel courses and Visintini beams (middle) and plate from *RFG report* showing the modular relationships of the panels of the standardized Frankfurt System (bottom).

Sources: *Das Neue Frankfurt* 2 (December 1926). 35, 36, 38; "Bericht Uber Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 110.



Fig. 191. Plates from *Das Neue Frankfurt* showing simple, adjustable formwork used in casting Frankfurt system panels (top) and the manual stamping, required by the SPD (bottom).

Source: *Das Neue Frankfurt 2* (December 1926). 35.



Fig. 192. Plate from *RFG report* showing typical one-meter wide panel, with rough finish and reinforcing, for transport, visible.

Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 40.

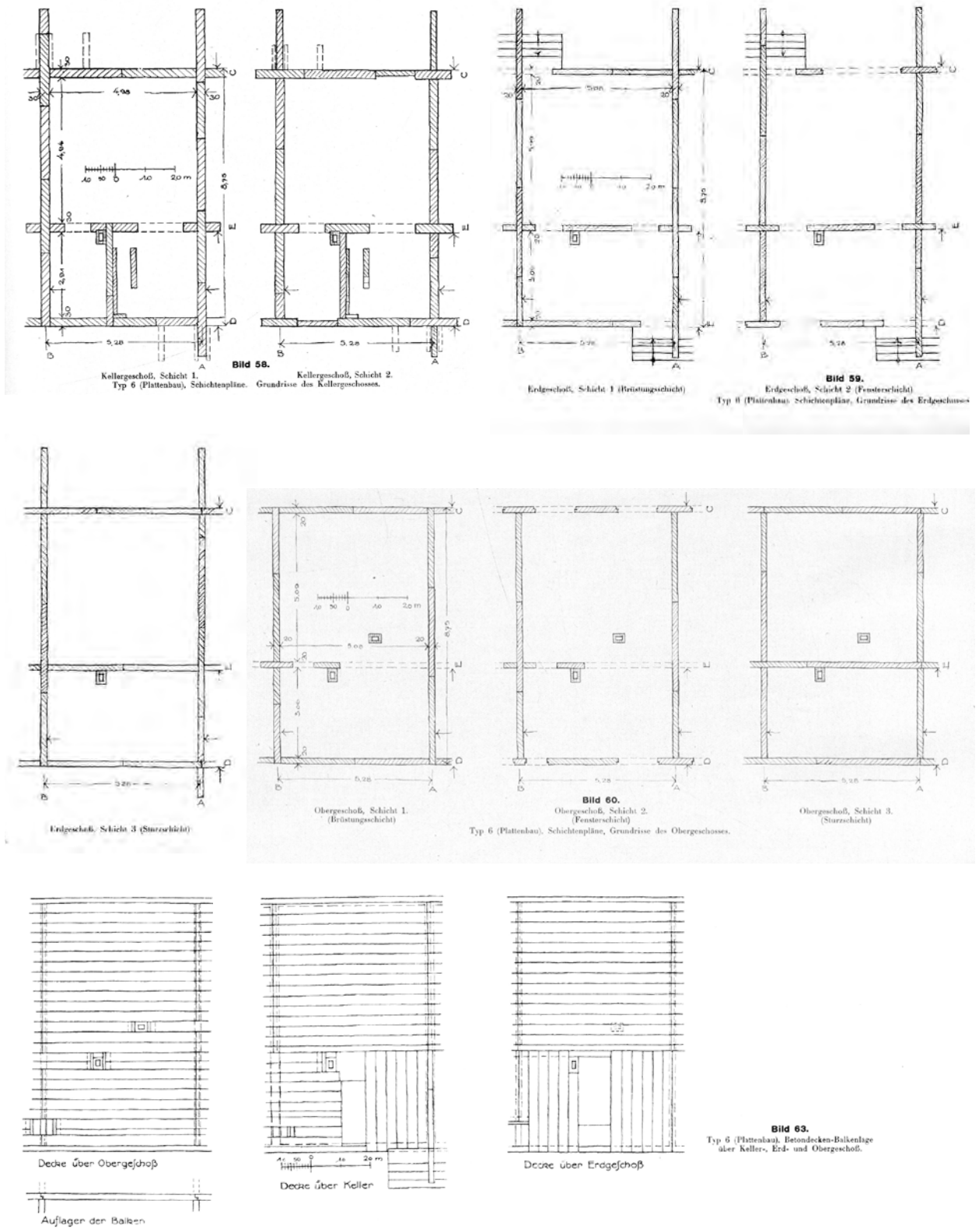


Fig. 193. Plates from RFG report showing plan views of every course of Frankfurt panels for a Type 6 unit. Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." RFG Sonderheft Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 47-50.

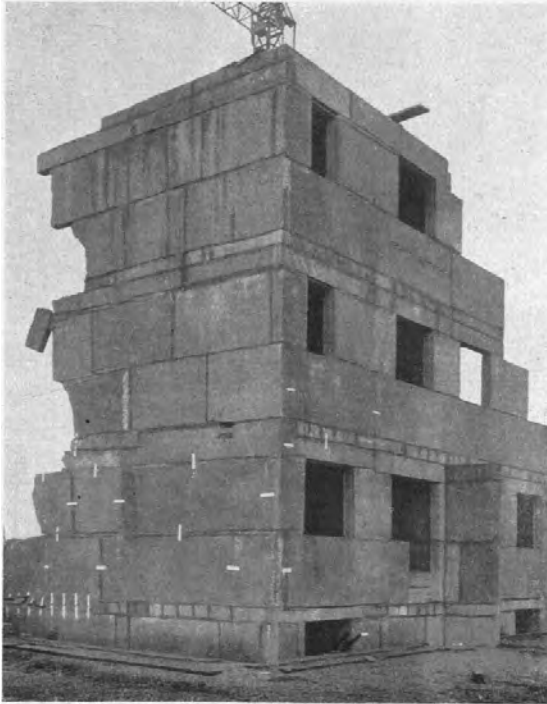


Bild 100.

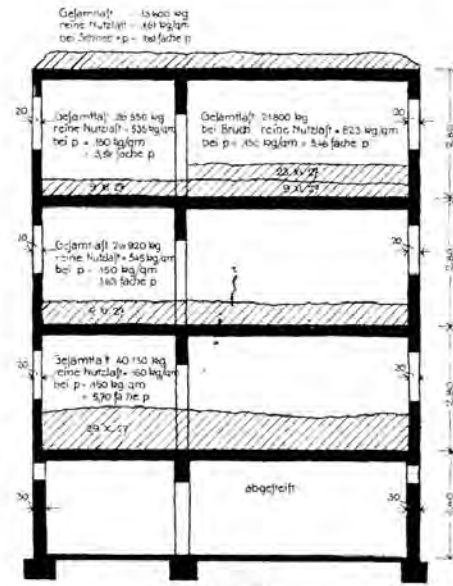


Bild 98.

3-geschossiges Platten-Probierhaus Dämmerstraße.
Belastungsschema, Querschnitt.



Bild 101.



Bild 104.

Fig. 195. Plates from RFG report showing the first experimental unit of the Frankfurt panel system, June 1926. Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." RFG Sonderheft Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 104-05.

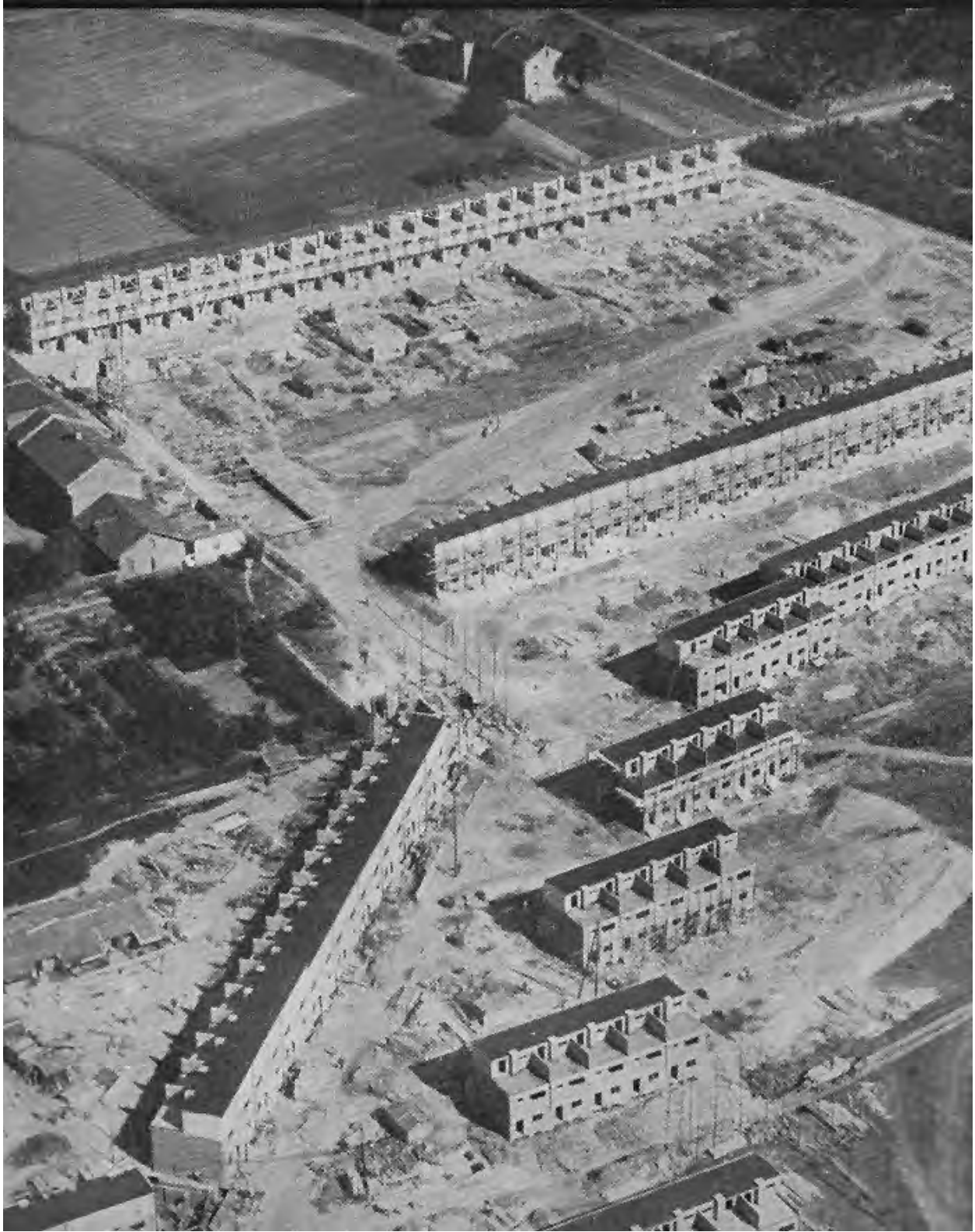


Fig. 196. Plate from *Das Neue Frankfurt* of photograph of Praunheim Phase I, with the standard brick construction units nearing completion and the foundations of the ten experimental Frankfurt panel system units under construction, 1926.

Source: *Das Neue Frankfurt* 1 (October 1926).

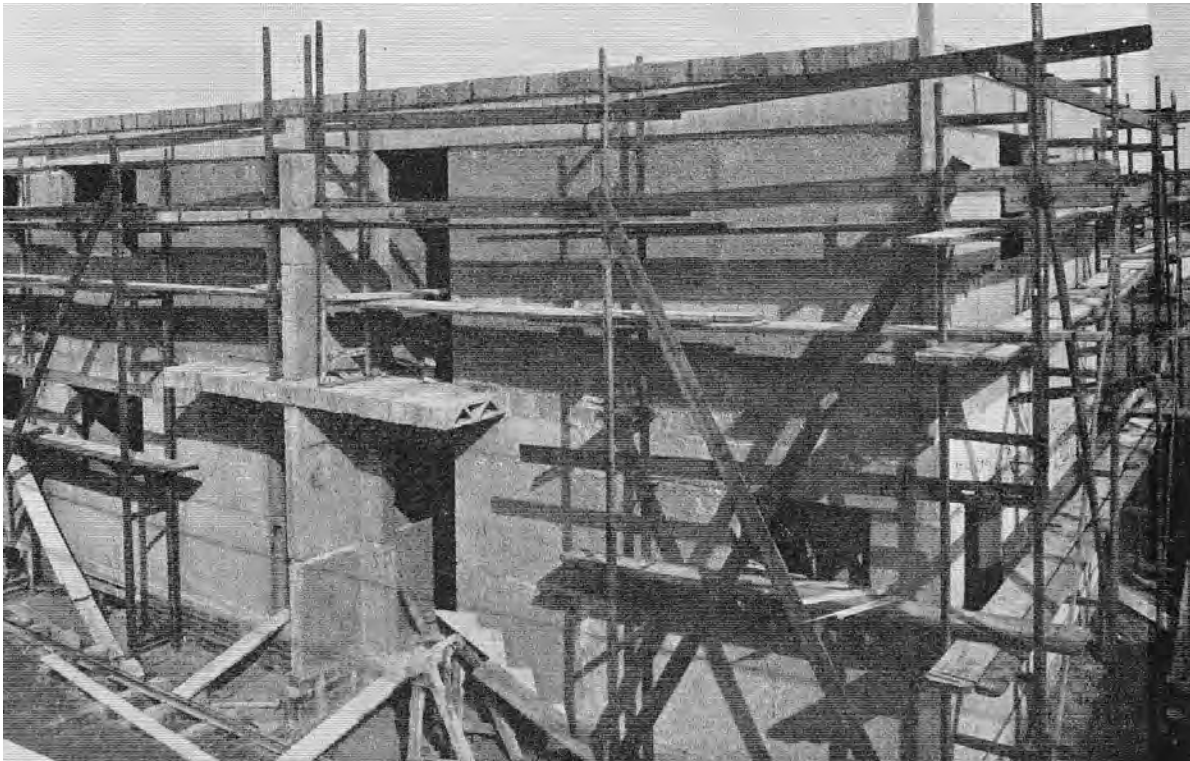
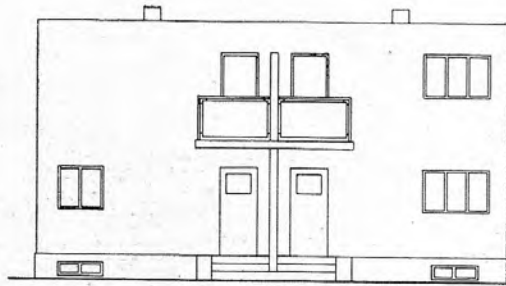
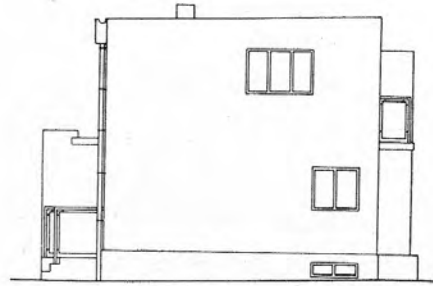


Fig. 197. Plate from *Das Neue Frankfurt* of photographs of experimental panel units, Praunheim Phase I, with two courses still to assemble (top) and fully assembled, with scaffolding erected for stucco application (bottom), 1926.

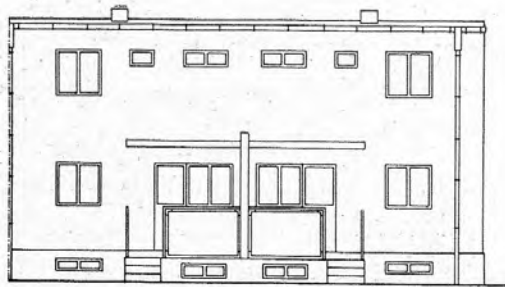
Source: *Das Neue Frankfurt* 2 (December 1926). 39.



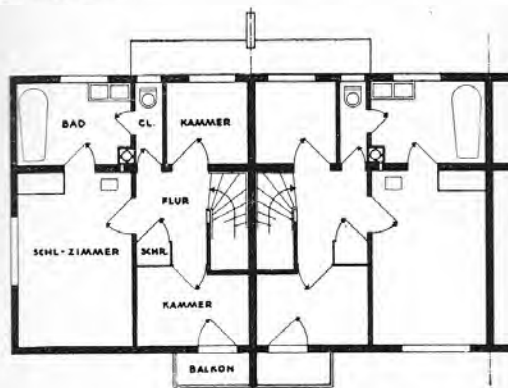
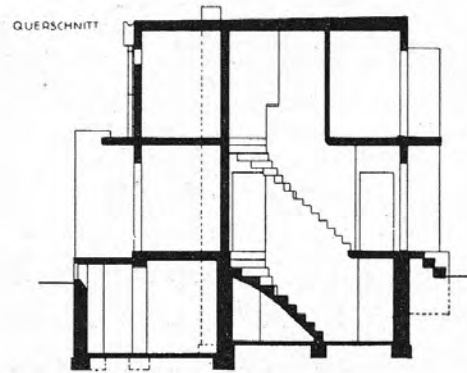
STRASSENANSICHT



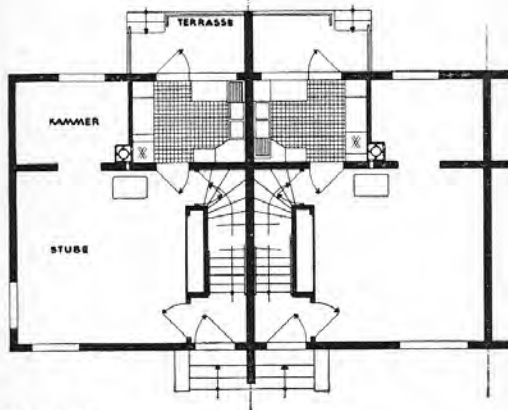
GIEBELANSICHT



GARTENANSICHT



OBERGESCHOSS



ERDGESCHOSS

Bild 18: Grundrisse vom Plattendtyp

Fig. 198. Plates from *Das Neue Frankfurt* showing elevations, section and plans of an experimental panel unit, Praunheim Phase I. Source: *Das Neue Frankfurt 2* (December 1926). 38.

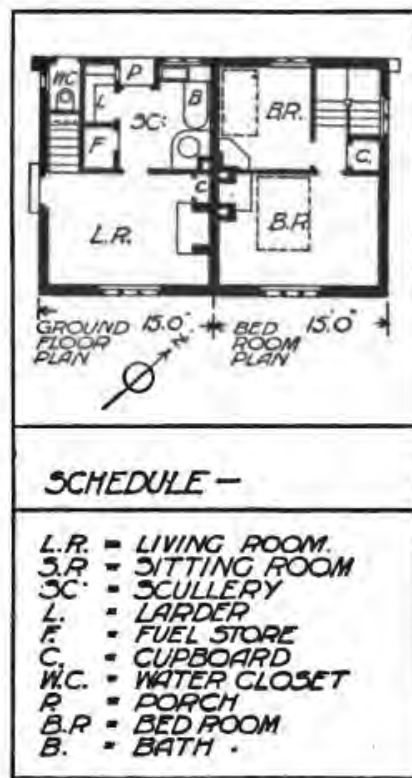


Fig. 199. Plate from *Town Planning in Practice* showing a cottage plan used at Hampstead Garden Suburb, with a scullery kitchen.

Source: *Town Planning in Practice*, 1909. 326.

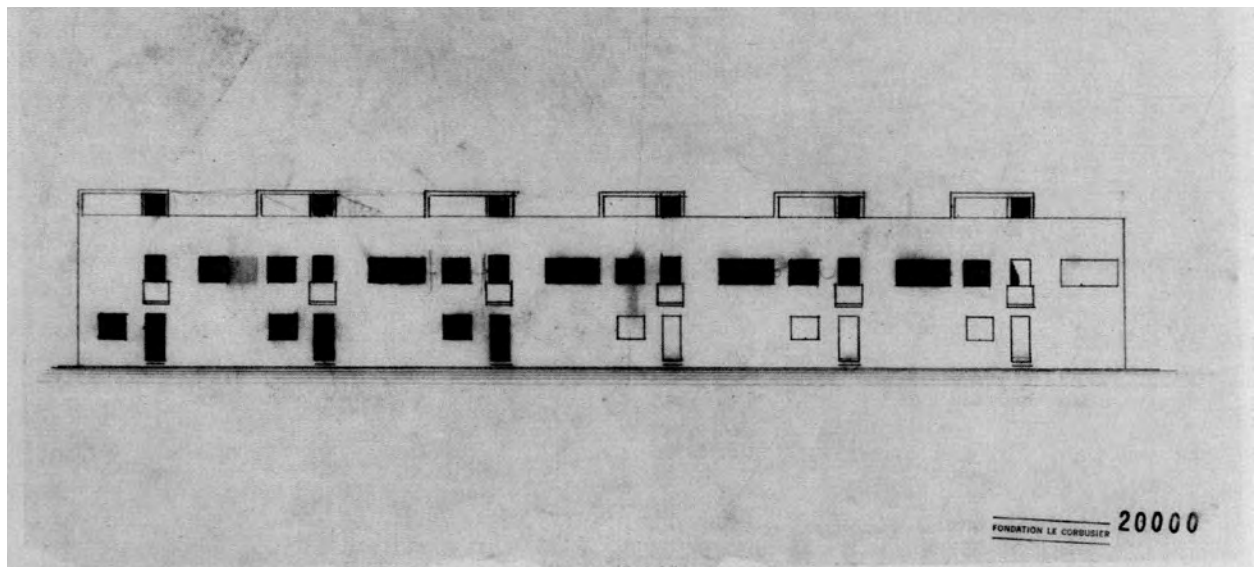


Fig. 200. Le Corbusier. Elevation study of row-houses in a series for Pessac, Sector C and D, 1926. See Fig. 132.

Source: FLC 20000.

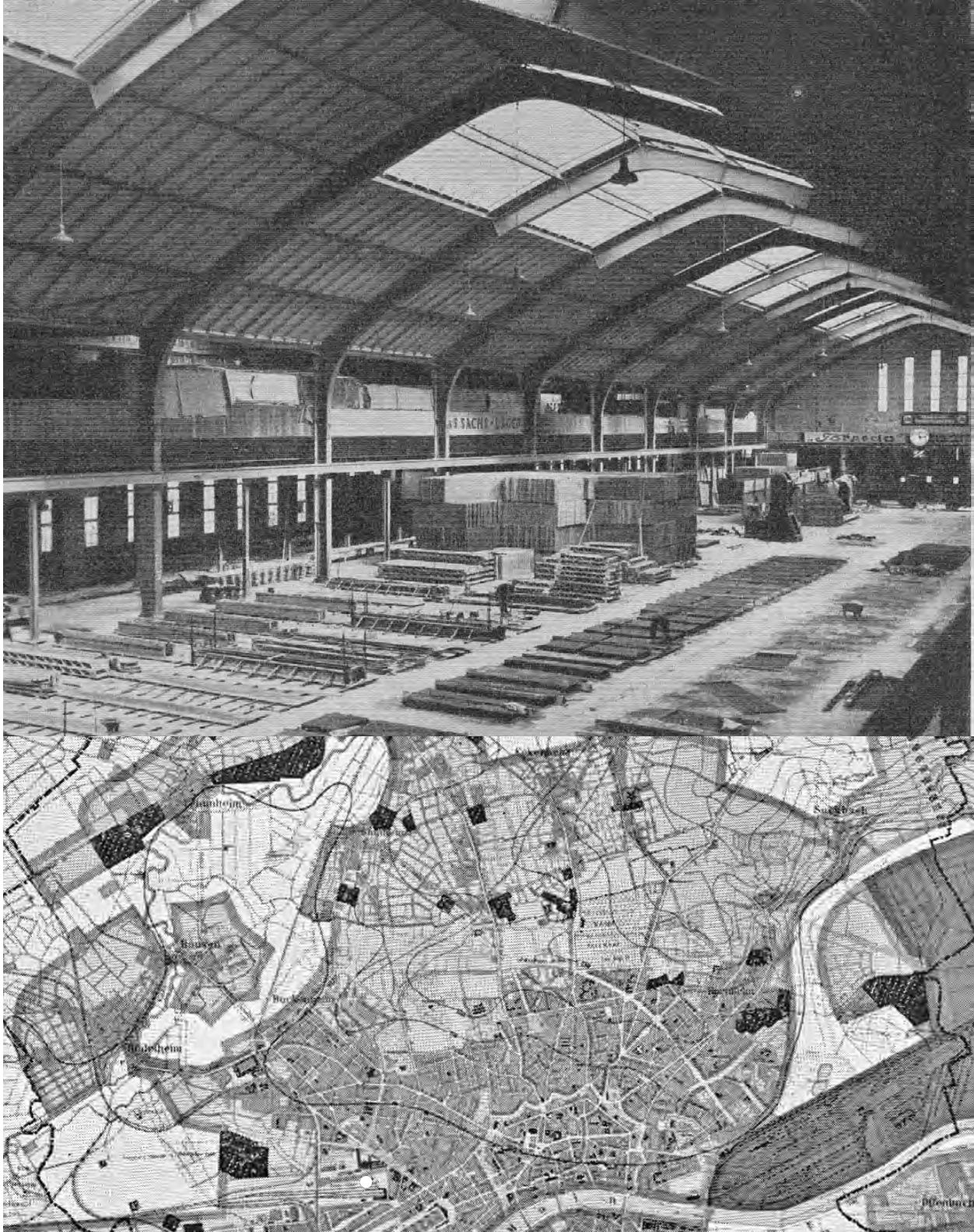
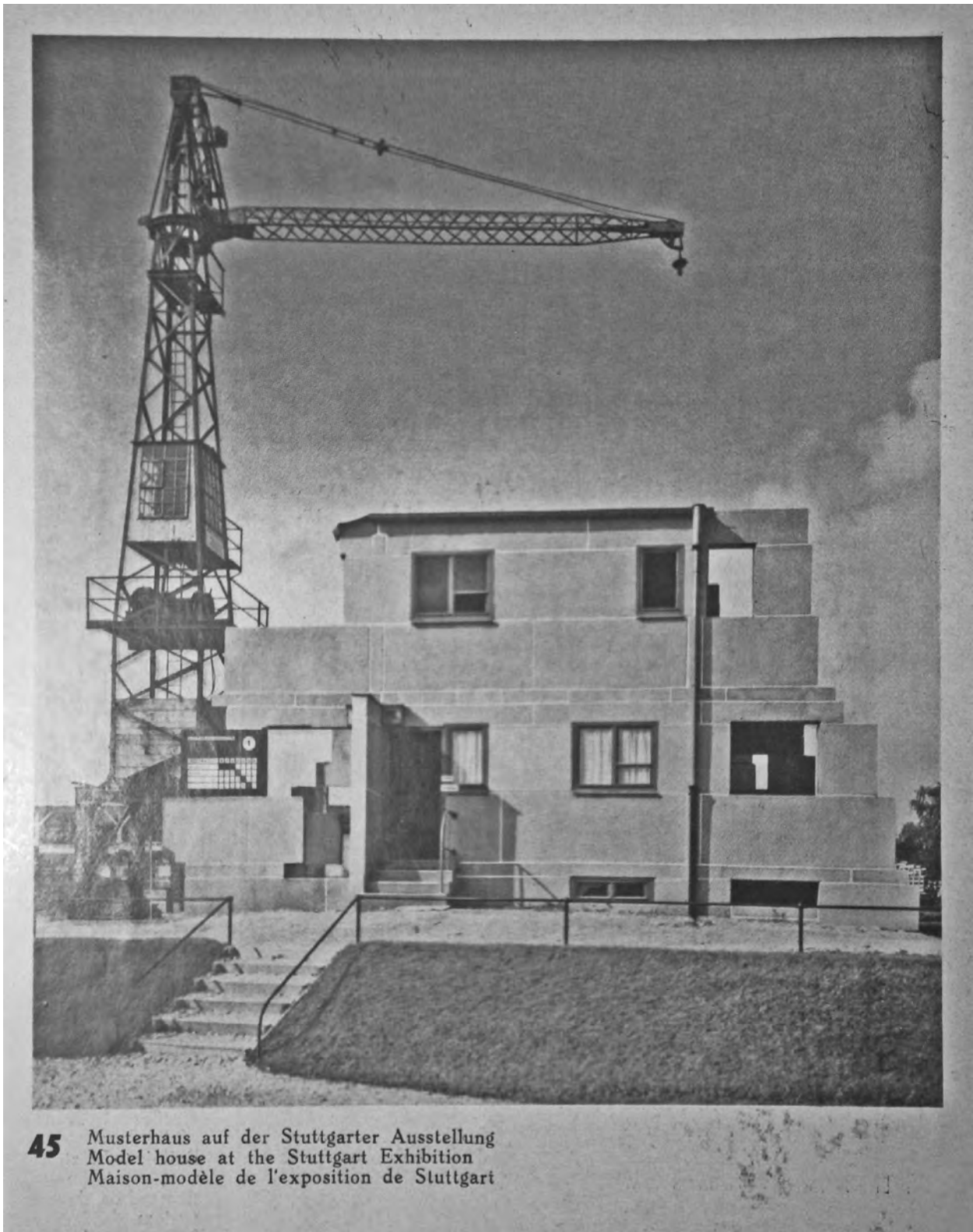


Fig. 201. Plate from *Das Neue Frankfurt* showing photograph of interior of the Haus der Technik at the Frankfurter Fair, where the panels for Praunheim Phase I and II and Mammolsheimerstrasse were fabricated between 1926 and 1928 (top) and the location of the fair (white dot) (bottom).
Source: *Das Neue Frankfurt* 2 (December 1926). 34.



45 Musterhaus auf der Stuttgarter Ausstellung
Model house at the Stuttgart Exhibition
Maison-modèle de l'exposition de Stuttgart

Fig. 202. Plate from *Das Neue Frankfurt* showing Frankfurt panel system exhibited in Stuttgart in 1927.
Source: May, Ernst. "Housing Policy of Frankfurt." *Das Neue Frankfurt* Special Edition (January 12, 1929). 45.

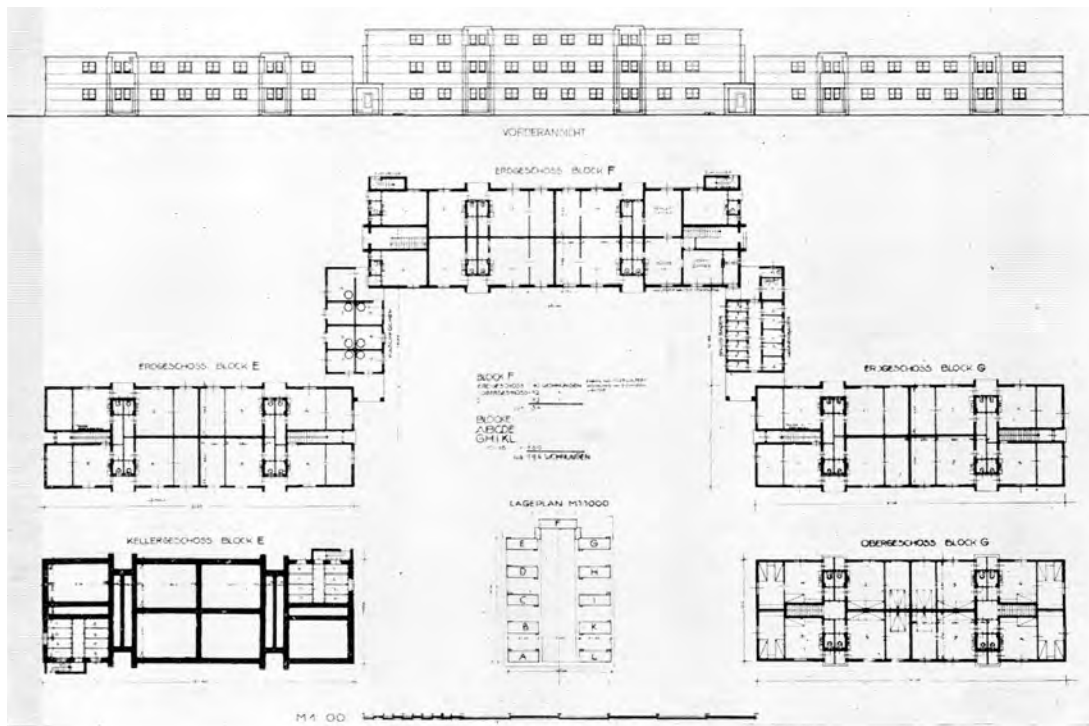
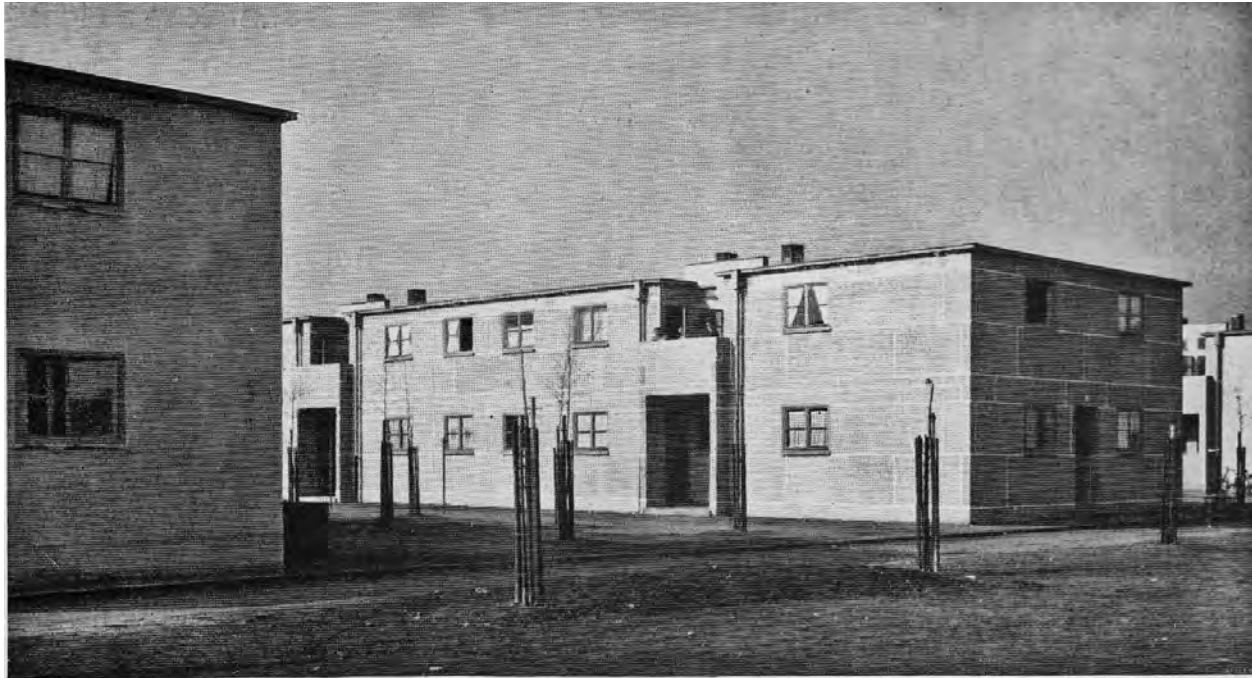


Fig. 203. Plate from *Das Neue Frankfurt* showing settlement and unit plans of Mammolsheinerstrasse. Source: *Das Neue Frankfurt* 8 (August 1928). 150.



Fig. 204. Plate from *Das Neue Frankfurt* showing assembly of panels at Mammolsheinerstrasse, 1928. Source: *Das Neue Frankfurt* 8 (August 1928). 122.



ANSICHT EINES BLOCKS AUS PLATTEN, DIE BEREITS IN DER FABRIK VERPUTZT WURDEN
Photo Collifchonn

Fig. 205. Plate from *Das Neue Frankfurt* showing use of concrete panels with stucco applied at the factory and joint lines visible, at Mammolsheinerstrasse, 1928.

Source: *Das Neue Frankfurt* 8 (August 1928). 151.

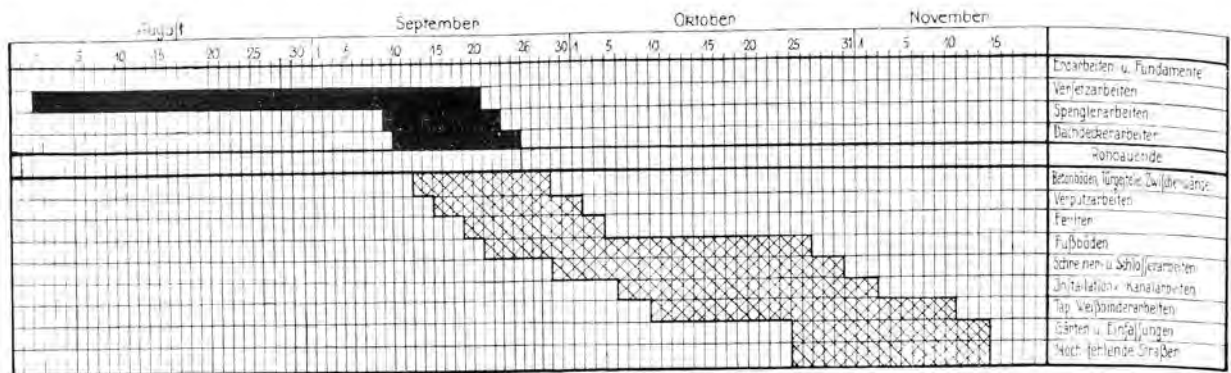


Bild 92.

Vor Baubeginn aufgestellter Bauzeitenplan für die Plattensiedlung in Praunheim.
 Los IV für insgesamt 57 Häuser (34 Häuser Typ 5 und 23 Häuser Typ 6).

Fig. 206. Plate from *RFG report* showing Gantt chart used to plan Praunheim Phase II experimental units Types 5 and 6, 1928.

Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 94.

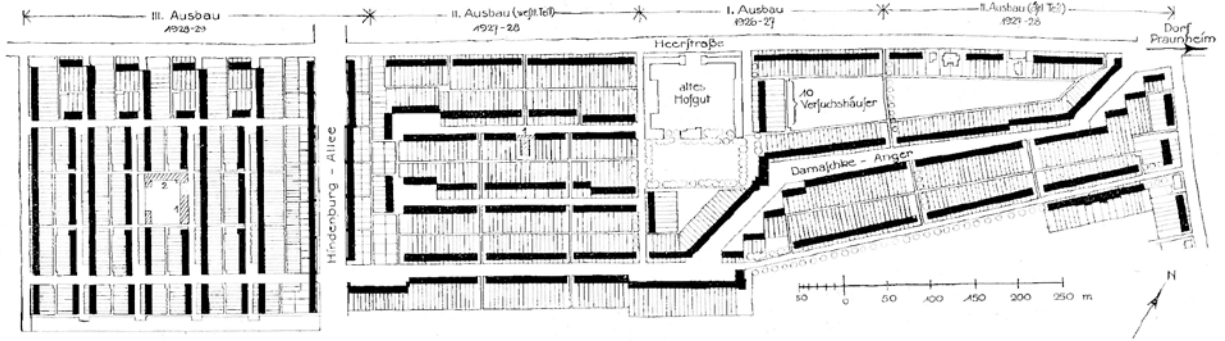


Bild 1. Gesamtlageplan der Siedlung Frankfurt-Pranheim, I., II. und III. Ausbau (1 = Wäscherei, 2 = Kindergarten).

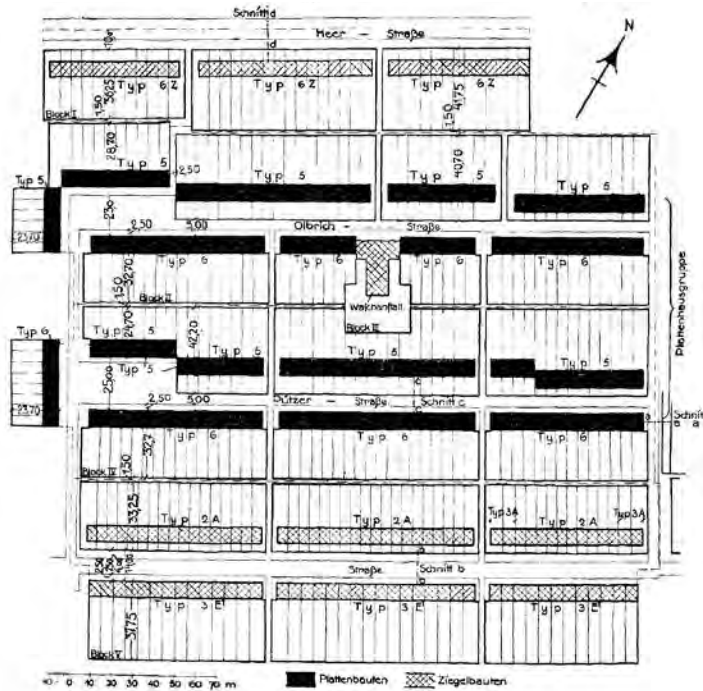


Bild 2. Lageplan der Siedlung Frankfurt-Pranheim, II. Ausbau, westl. Teil.

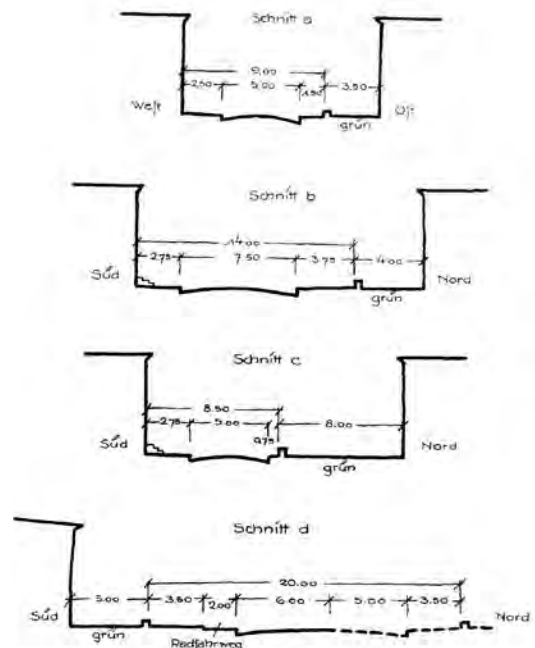


Bild 3. Straßenprofile der Siedlung Frankfurt-Pranheim, II. Ausbau, westl. Teil. (Die angegebenen Schnitte a bis d sind im Lageplan, Bild 2, eingetragen.)

Auswertungstabelle:

Block Nr.	Art der Bebauung	Gesamte Fläche m ²	Fläche des Bau-landes m ²	Fläche der Straße m ²	Hausform	Zahl der Ge-schosse	Zahl der Woh-nung.	Auf eine Wohnung entfallen:		
								Straßen-fläche m ²	Bau-land m ²	Insgesamt m ²
I	Wohnblock	10749,50	7905,00	2844,50	1 Fam.-Haus 2 Gesch.	—	41	69,38	192,80	262,18
II	„	23391,01	19112,80	4278,21	„	„	100	42,78	191,13	233,91
III	Waschanst.	1296,99	1120,02	176,97	—	—	—	—	—	—
IV	Wohnblock	24162,75	20166,93	3995,82	1 Fam.-Haus 2 Gesch.	—	104	38,42	193,91	232,33
V	„	23431,25	18741,62	4692,63	„	„	92	51,01	203,71	254,72
I—V Zusammen		83034,50	67046,37	15988,13			337	47,44	198,95	246,39
								im mittel		

Fig. 207. Plates from RFG report showing the three phases at Pranheim (top), a settlement plan, indicated panel and brick units, and street sections, of Phase II (middle) and a unit chart of Phase II (bottom). Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Pranheim (Frankfurter Montagebauverfahren)." RFG Sonderheft Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 6, 13.

SIEDLUNG PRAUNHEIM

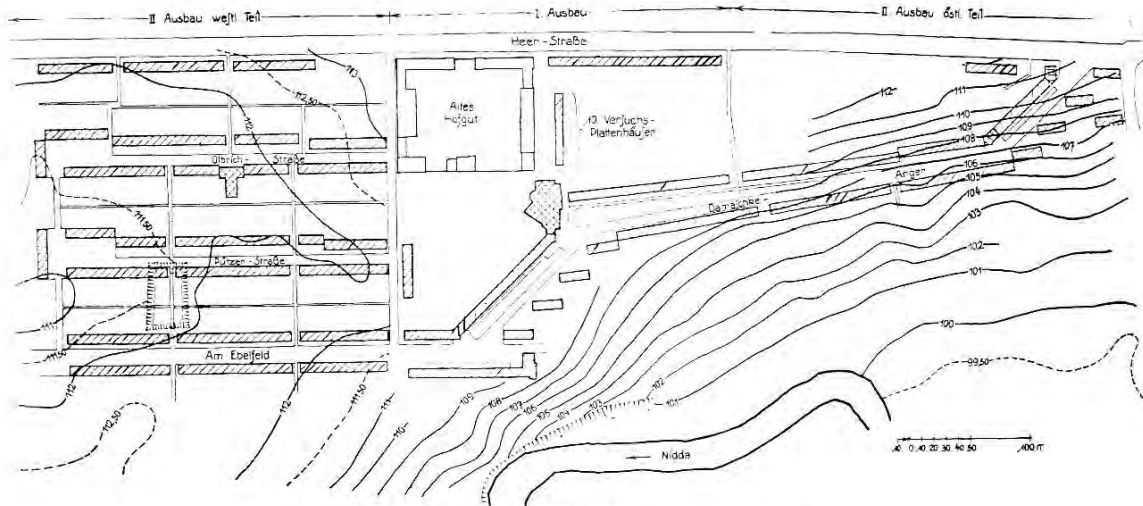
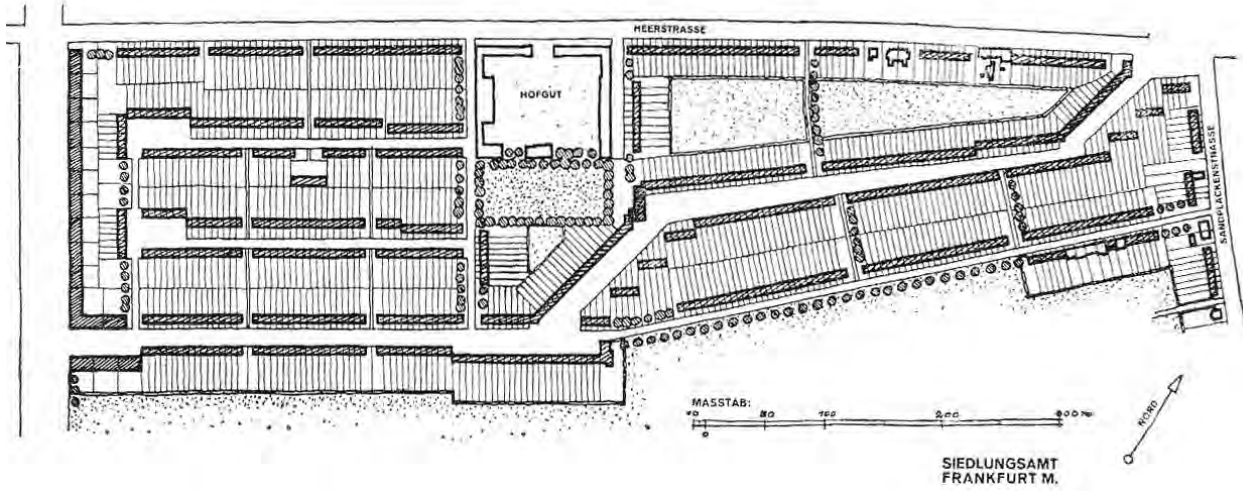


Bild 3.

Höhenlinienplan der Siedlung Frankfurt-Praunheim. I. u. II. Ausbau.

Fig. 208. Plate from *Das Neue Frankfurt* showing Praunheim Phase I and II Settlement plan, 1927 (top), and plate from RFG report showing Praunheim Phase I and II Settlement plan, 1928 (bottom).

Source: *Das Neue Frankfurt* 5 (May 1927). 109; "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 9.

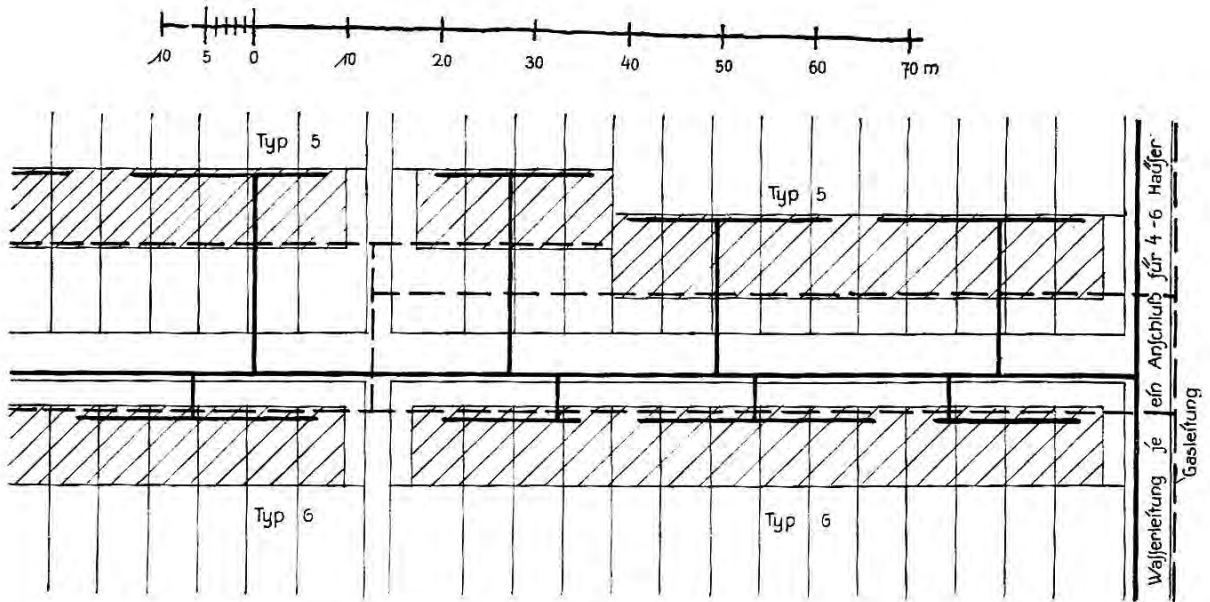


Bild 6.
 Straßenberohrung und Hausanschlüsse: Gas- und Wasserleitung. Für die Bewässerungsleitung ist je ein Anschluß für 4-6 Häuser gewählt.

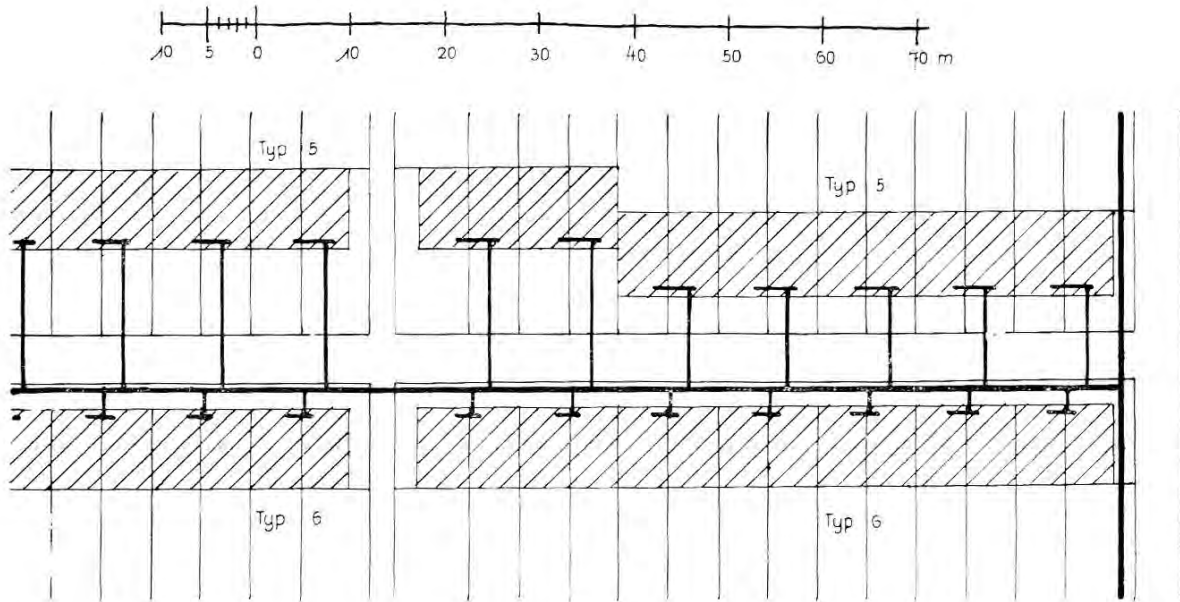


Bild 7.
 Straßenberohrung und Hausanschlüsse: Elektrische Leitung, je ein Anschluß für 2 Häuser.

Fig. 209. Plates from *RFG report* showing the planning of gas and water (top) and electrical (bottom) infrastructure at Praunheim Phase II, to be constructed to assist construction as well as occupation. Compare to Fig. 45.

Source: Source: "Bericht Über Die Versuchssiedlung in Frankfurt A. M.-Praunheim (Frankfurter Montagebauverfahren)." *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 12.

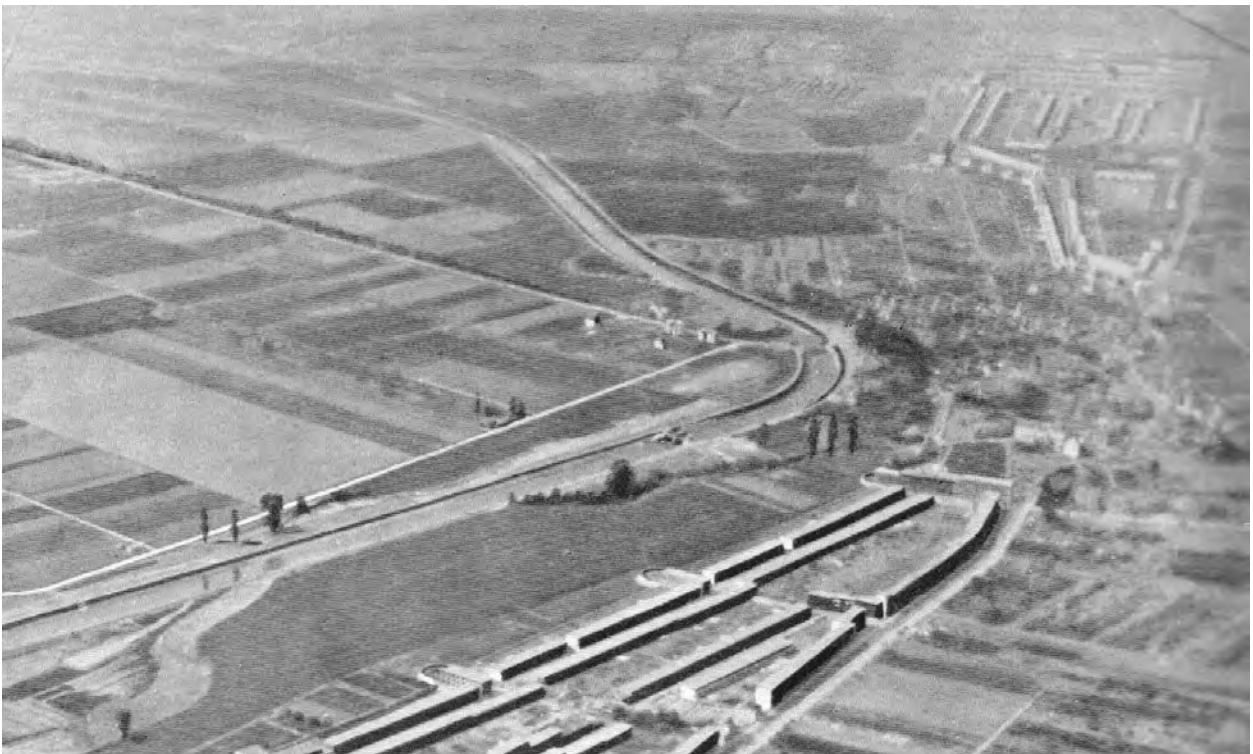


Fig. 210. Plates from *Das Neue Frankfurt* showing Praunheim Phase II from the west (top) from the south (middle) and from the east, with Phase III starting, and with Rommerstadt Settlement in foreground (bottom). Sources: *Das Neue Frankfurt* 8 (August 1928). 126; Ibid. 127; *Das Neue Frankfurt* 5 (May 1930). 84.

DER WEG VOM ZIEGELMAUERWERK ZUM FRANKFURTER MONTAGEVERFAHREN

NACHTEILE DES ZIEGELBAUS.

1. Der Ziegel ist zu klein. Das Vermauern verflingt daher unnötigen Lohn.

2. Beim Vermauern der Ziegel wird eine große Menge Feuchtigkeit in den Baukörper gebracht, die wieder daraus entfernt werden muß, was die Bauzeit verlängert, das Bauen verteuert.

3. Die Maurer können weder bei Frost noch bei starkem Regen arbeiten. Das Bauhandwerk ist Saisonhandwerk.

4. Die Ziegelmauer ist viel zu tragfähig für die Belastungen, die ihr im Wohnungsbau, besonders im Kleinhäusbau, zugemutet werden.

5. Die langsame Bauerzeugung verlängert die Bauzeit und verteuert den Bau.

6. Der Ziegelbau kann nur von gelerntem Bauarbeitern ausgeführt werden, die heute knapp sind; die große Mehrzahl der Frankfurter Bauarbeiter kommt von auswärts.

7. Die Möglichkeit, jede noch so willkürliche Form mittels des Ziegels herzustellen, verführt den Architekten zur Unfachlichkeit.

FORDERUNGEN, DIE SICH AUS DEN MINDELEN DES ZIEGELBAUES ERGEBEN.

1. Das Format der Hausbauteile muß so beschaffen sein, daß mit möglichst wenig Lohnarbeit ein möglichst großer Effekt erzielt wird.

2. Die Bauteile sollen trocken an die Baustelle gebracht werden. Die Fugenzahl soll auf das notwendige Maß beschränkt werden.

3. Das Bauhandwerk muß unabhängig von der Witterung gemacht, aus einem Saisongewerbe in ein Dauergerwerb verwandelt werden.

4. Die einzelnen Bauteile sollen einen gefunden Ausgleich zwischen statischen und wärmetechnischen Forderungen gewährleisten.

5. Die Bauzeit ist auf ein Minimum zu reduzieren. Zeiterparnis bedeutet Gelderparnis.

6. Dasjenige Bauverfahren wird am ehesten zur Linderung der Erwerbslosigkeit beitragen, das die Beschäftigung ungelerner Arbeiter ermöglicht.

7. Der Baukörper soll die Konfektion nicht verhüllen, sondern aus ihren Geleiten geradezu seine Schönheit mit herleiten.

ERFÜLLUNG DIESER FORDERUNGEN DURCH DAS FRANKFURTER MONTAGEVERFAHREN.

1. Es werden Normenplatten von 3 m Länge, 1,10 m Höhe und 20 cm Stärke verwendet und mittels Kran montiert.

2. Die Einheitskörper werden in der Fabrik erzeugt, trocken an die Baustelle gebracht und mit einem Mindestmaß von Fugen verlegt.

3. Die Bauteile nach dem Frankfurter Montageverfahren werden im geschlossenen Raum unabhängig von der Witterung fabriziert und an der Baustelle in wenigen Tagen zusammengeführt.

4. Die Außenwandplatten nach dem Frankfurter Montageverfahren sind nur, so stark wie dies für den Zweck, für den sie bestimmt sind, erforderlich ist. Die Wärmeisolerfähigkeit ist günstiger als die der Normalziegelmauer.

5. Zur Herstellung der Einheitsaufplatte auf malchinellem Wege sind 3—5 Minuten erforderlich, zur Herstellung von Hand aus 25 Minuten. Die komplette Montage der Platte auf der Baustelle erfordert weitere 30 Minuten. Zur Herstellung eines Stückes Ziegelmauer gleichen Effektes wird eine Zeit von 5—6 Stunden benötigt. Die Bauzeit wird von 5—6 Monaten herabgedrückt auf 1—2 Monate einschließlich Ausbau.

6. Die Erzeugung der Bauelemente kann durch ungelernete Arbeiter erfolgen. Die Montage erfolgt durch Bauhandwerker.

7. Das Montageverfahren zwingt zur Sachlichkeit und Klarheit in der Formgebung.

40

I. PLATTENBAUTEN

Die Kosten für einen cbm Plattenwand im Rohbau verteilen sich wie folgt:

1. Plattenmaterialien einschließlich der Stürze und Ausgleichslücke ab Werk verladen für 1 cbm	45,— Mk.
2. Transport der Plattenmaterialien frei Bau	4,— "
3. Verlegen der Platten (Montage) einschließlich der noch erforderlichen Materialien, Gerüste und die Verwendung des Kranes	18,— "
zusammen je cbm	67,— Mk.

Für 1 qm 20 cm Plattenwand fertig verlegt: $67,00 \times 0,30 = 20,10$ "

Für 1 qm 30 cm Plattenwand fertig verlegt: $67,00 \times 0,30 = 20,10$ "

Vergleichsberechnung:

II. ZIEGELBAUTEN

1. Materialbedarf für 1 cbm

a) 380 Mauersteine à 39,00/1000 Stück	14,82 Mk.
b) Transport frei Bau à 7,50/1000 Stück	2,85 "
c) 280 Lt. Mörtel à 15,00/1000 Lt	4,20 "
d) Zulage für sonstigen Materialbedarf, Zement, Eisen, 5% von 21,87	1,09 "
e) Für Unkosten und Verlust 14% von 22,96	3,21 "
	<u>26,17 Mk.</u>

2. Arbeitslohn

a) 4,5 Maurerlunden à 1,36	6,12 "
b) 2,5 Hilfsarbeiterlunden à 1,13	2,83 "
c) Zulage für Zulagarbeiten 5% von 8,95	0,45 "
	<u>9,40 "</u>

3. Sonstige Kosten

a) Soziale Latten und Aufsicht 20% von 9,40 Mk.	1,88 "
b) Vorhalten der Geräte pp. sowie Gefahrsunkosten 10% von 9,40	0,94 "
	<u>2,82 "</u>
c) Risiko und Gewinn 5% von 38,39 Mk.	1,92 "
	<u>40,31 Mk.</u>

Für 1 qm 38 cm Mauerwerk fertig vermauert einschließlich sämtlicher Zulagen $40,31 \times 0,38$ gleich 15,32 Mk.

Für 1 qm 51 cm Mauerwerk fertig vermauert einschließlich sämtlicher Zulagen $40,31 \times 0,51$ gleich 20,56 Mk.

Die Erfahrungen, die bisher mit dem Montageverfahren gemacht wurden, sind günstige. Die technischen Eigenschaften der neuen Bauweise übertreffen die alte Ziegelbauweise in verschiedener Hinsicht. Während der sehr strengen Wintermonate vergangenen Jahres war allgemein festzustellen, daß die Häuser wärmer waren, als die gleichzeitig errichteten mit 30 cm starken Hohlziegelwänden. Wie aus der obigen Berechnung hervorgeht, sind heute schon die Herstellungskosten des typisierten Plattenhauses niedriger als die des Ziegelhauses von 38 cm Wandstärke.

44

Fig. 211. Plate from *Das Neue Frankfurt* comparing brick construction and Frankfurt system panel construction, prior to the start of experimentation and standardization, in 1926 (top) and plate from *DNF* comparing Frankfurt system panel construction and brick construction after the system was experimentally derived and significantly standardized, in 1930 (bottom).

Sources: *Das Neue Frankfurt* 2 (December 1926). 40; *Das Neue Frankfurt* 3 (March 1930). 44.

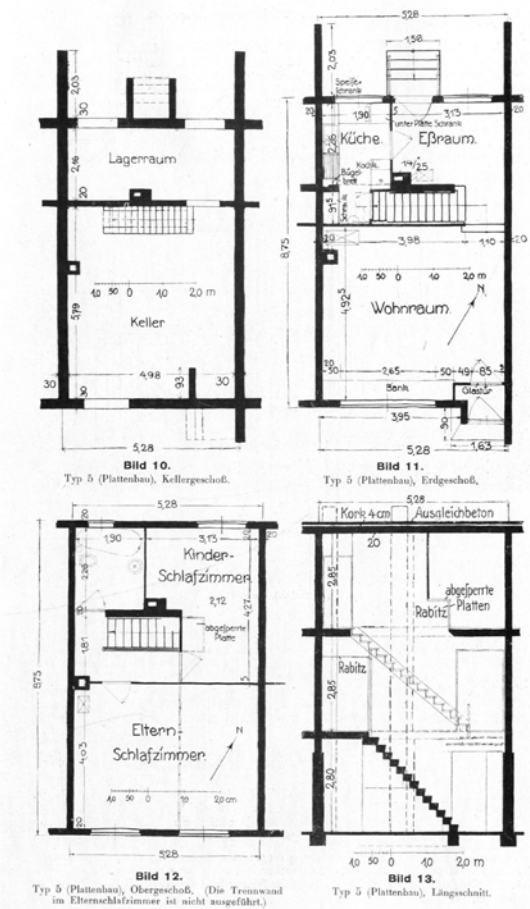


Fig. 213. Floor plans and sections of Type 5, Praunheim Phase II.
Source: RFG Sonderheft Nr. 4, no. Gruppe IV, NR. 2 (April 1929), 15-16.

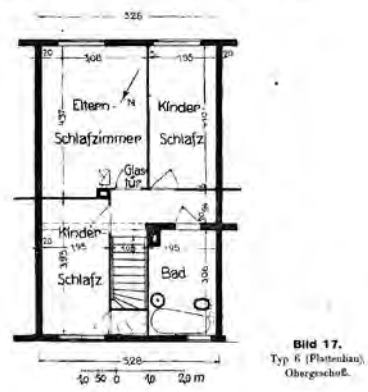
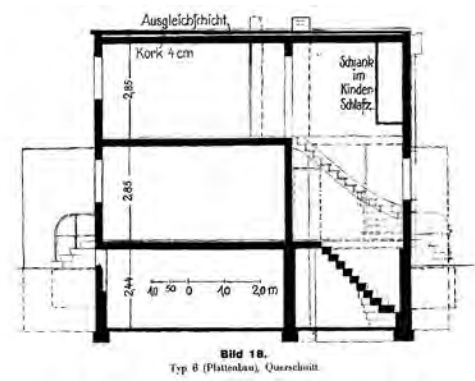
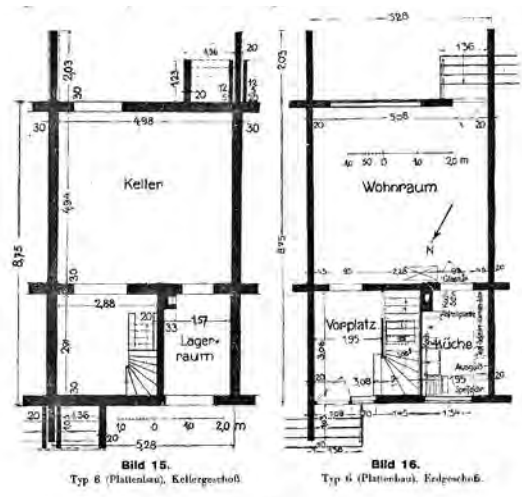
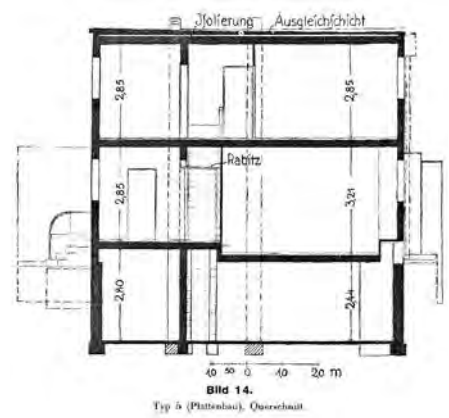


Fig. 214. Floor plans and sections of Type 6, Praunheim Phase II.
Source: RFG Sonderheft Nr. 4, no. Gruppe IV, NR. 2 (April 1929), 17-18.

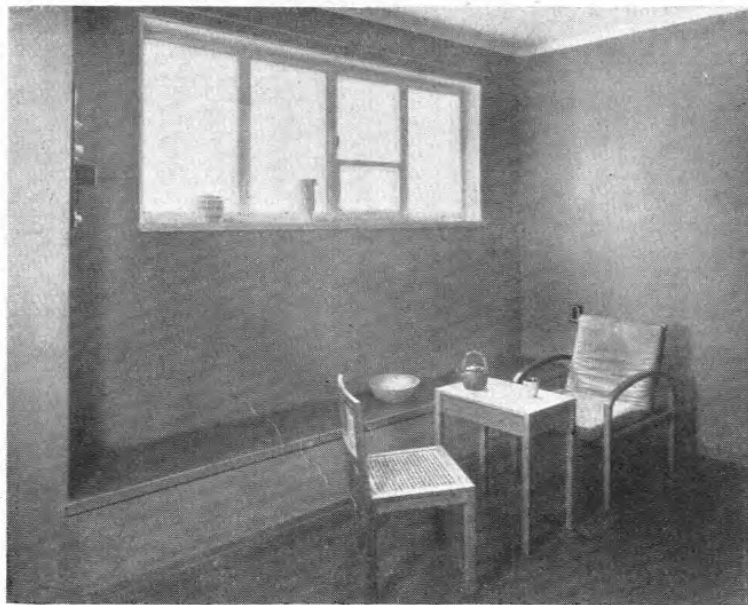


Bild 22.

Typ 5. Bank unter dem Fenster im Wohnraum. (Unterhalb der Bank liegt das Fenster zur Belichtung des Kellers, s. Schnitt in Bild 14.)

Fig. 215. Plates from RFG report showing living room of Type 5, with adjusted floor height visible.
Source: *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 20.



Bild 44.

Typ 6 (Plattenhaus) Wohnraum. Die im Text beschriebene Türkonstruktion ist aus Bild 82 zu entnehmen.

Aus: *Das Neue Frankfurt*, 1926/27, Heft 6, Verlag Englert u. Schlosser, Frankfurt a. M.

Fig. 216. Plates from RFG report showing living room of Type 6.
Source: *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 38.

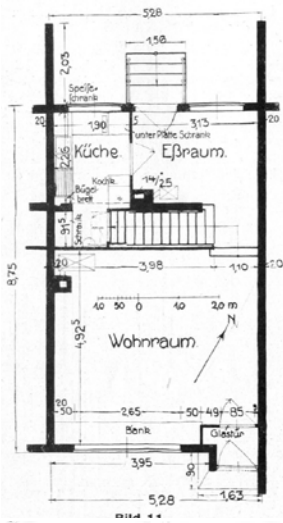


Bild 25. Frankfurter Küche.
 Teil-Abdruck von einem Frankfurter Normenblatt. Die Küche ist 1,87 m × 3,44 m groß und enthält:
 1 = Herd mit einer Abstellplatte, 7 = Spülschrank, 13 = Geschirrschrank,
 2 = Schabladen für Mehl und Salz, 8 = Tisch mit Rinnr für Kochgeschäfte, 14 = Topfschrank,
 3 = Kochtisch, 9 = Abtropfbrett, 15 = Mülle- und Restschrank,
 4 = Schabladen für größere Vorräte, 10 = Teilverabtopfplatte, 16 = Schmelzplatte,
 5 = Herdkörper, 11 = Zweiteiliges Spülbecken, 17 = Bügelgerät,
 6 = Geschirrstuhl, 12 = Vorratskasten.

Alle Möbel stehen auf 10 cm hohem Betonsockel, mit Platten bekleidet, der 4 cm ausreißt.

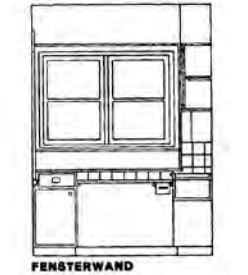
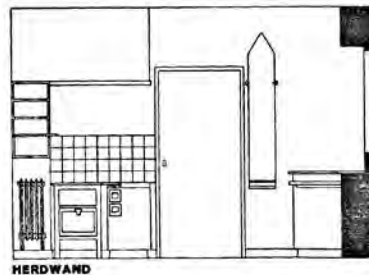
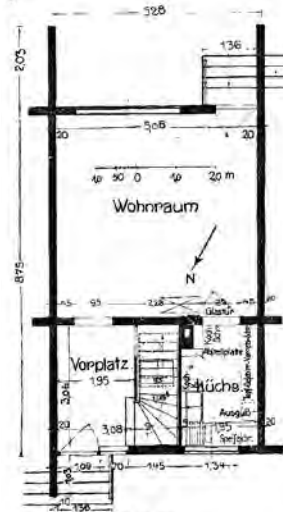
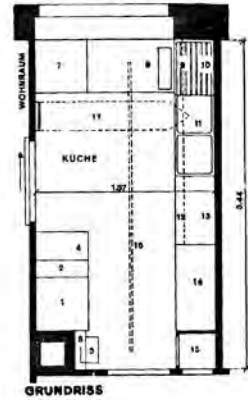
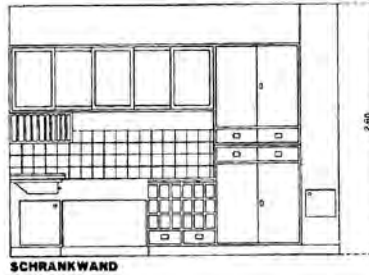


Bild 16.
 Typ 6 (Plattenbau), Erdgeschoss.

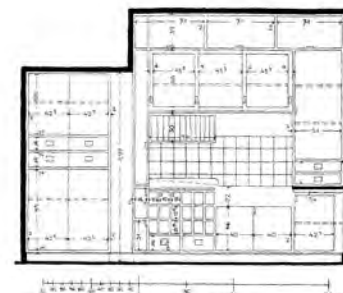
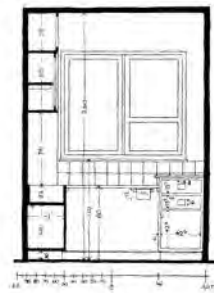
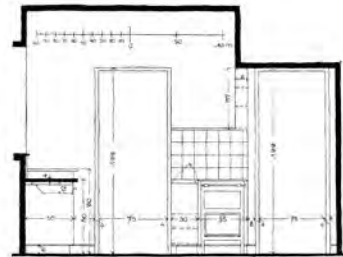
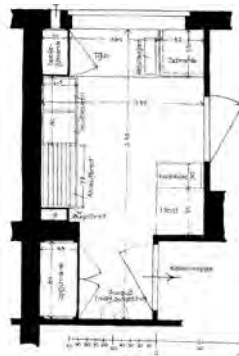
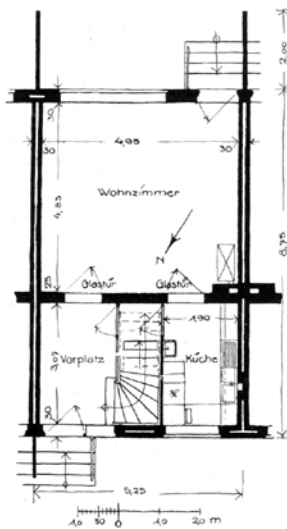


Fig. 217. Plans of Type 5, 6 and 6z, comparing their Frankfurt Kitchens (left) and plates from RFG showing two variants of the Frankfurt kitchen, including plans and interior elevations (right).
 Source: RFG Sonderheft Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 22, 30-32.



Bild 26.

Frankfurter Küche. Blick von der Flurtür in die Küche.
(Es wird besonders auf die zu vielen und zu niedrig angebrachten Schütten rechts aufmerksam gemacht.)

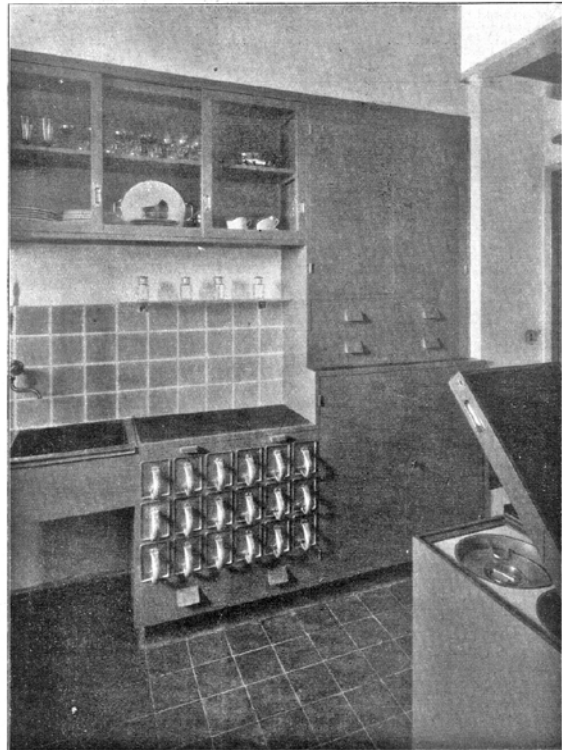


Bild 28.

Frankfurter Küche. Blick von der zum Wehrraum führenden Schiebetür auf Kochkiste, Spüle und Schränke.



Bild 31.

Frankfurter Küche. Topfschrank, geöffnet.
Unten eine flache Emailleschale mit darüberliegendem Rost zum Abstellen der Pfannen usw.

Fig. 218. Plates from RFG report showing interior of Frankfurt kitchen, with raw material stores visible (top) and drying rack (bottom).

Source: *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 23, 25, 28.



Bild 52.

Neue Frankfurter Plattenfabrik am Osthafen (Lage s. Bild 4). Blick auf das Fabrikationsgelände, von einem der beiden Portalkrane aus gesehen. Der zweite Portalkran ist links im Hintergrunde zu sehen.



Bild 53.

Einbringen des Bimsmaterials durch einen Dampfschwenkran in den Doppelsilo.



Bild 55.

Transport der fertigen Platten durch einen der beiden Portalkrane, die das ganze Fabrikationsgelände bestreichen. (Zu beachten ist das Verhältnis der Krangröße zu der bewegten Last.)

Fig. 219. Map of Frankfurt, showing the East Harbor (top) and plates from RFG report showing the casting yard at the East Harbor in late 1928 (middle) and mechanization available on site (bottom).
Source: *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 42-43.

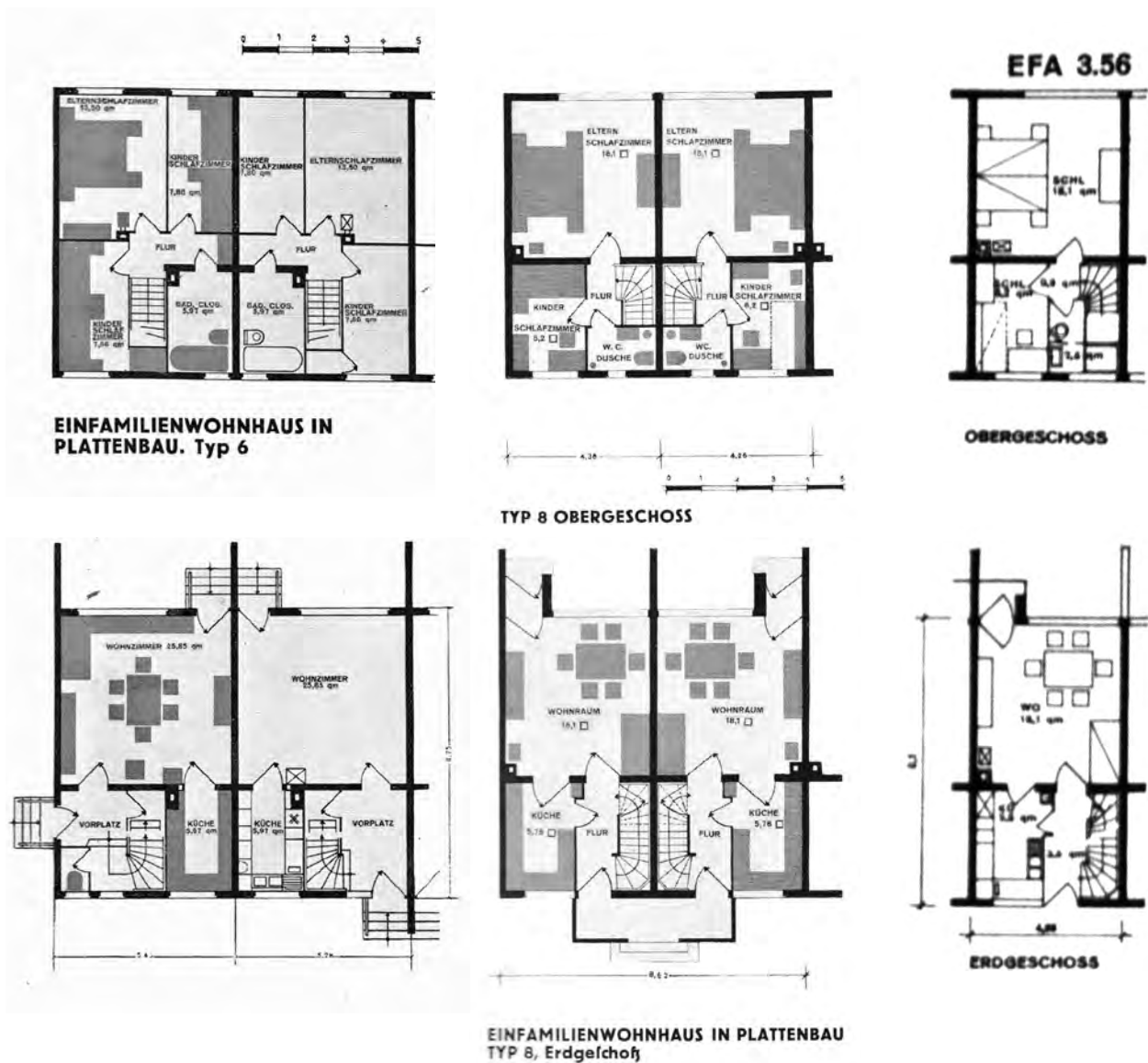


Fig. 220. Plans of Type 6, Phase II, Type 8, Phase III and a variant of Type 8, designated as a tentative standard, Type EFA 3.56.

Sources: *Das Neue Frankfurt* 8 (August 1928). 128; *Ibid.* 130; May, Ernst. "Housing Policy of Frankfurt." DNF Special Edition (January 12, 1929). 45.

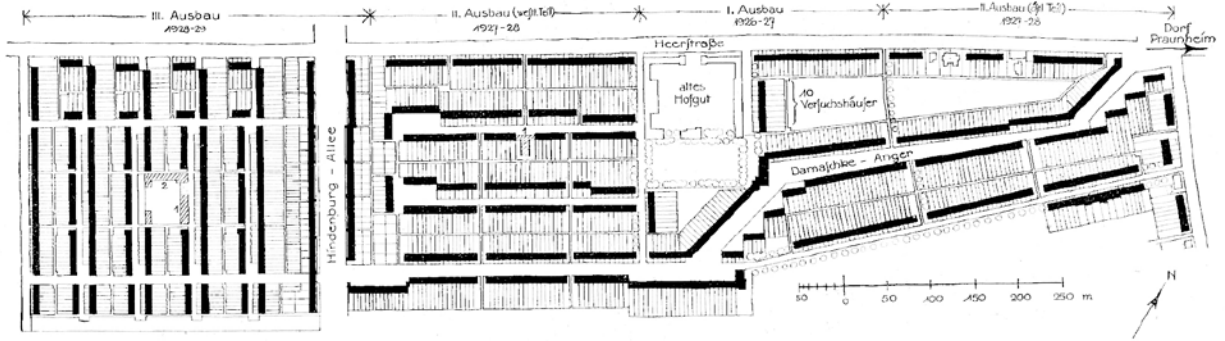


Bild 1.
Gesamtlageplan der Siedlung Frankfurt-Praunheim, I., II. und III. Ausbau (1 = Wäscherei, 2 = Kindergarten).

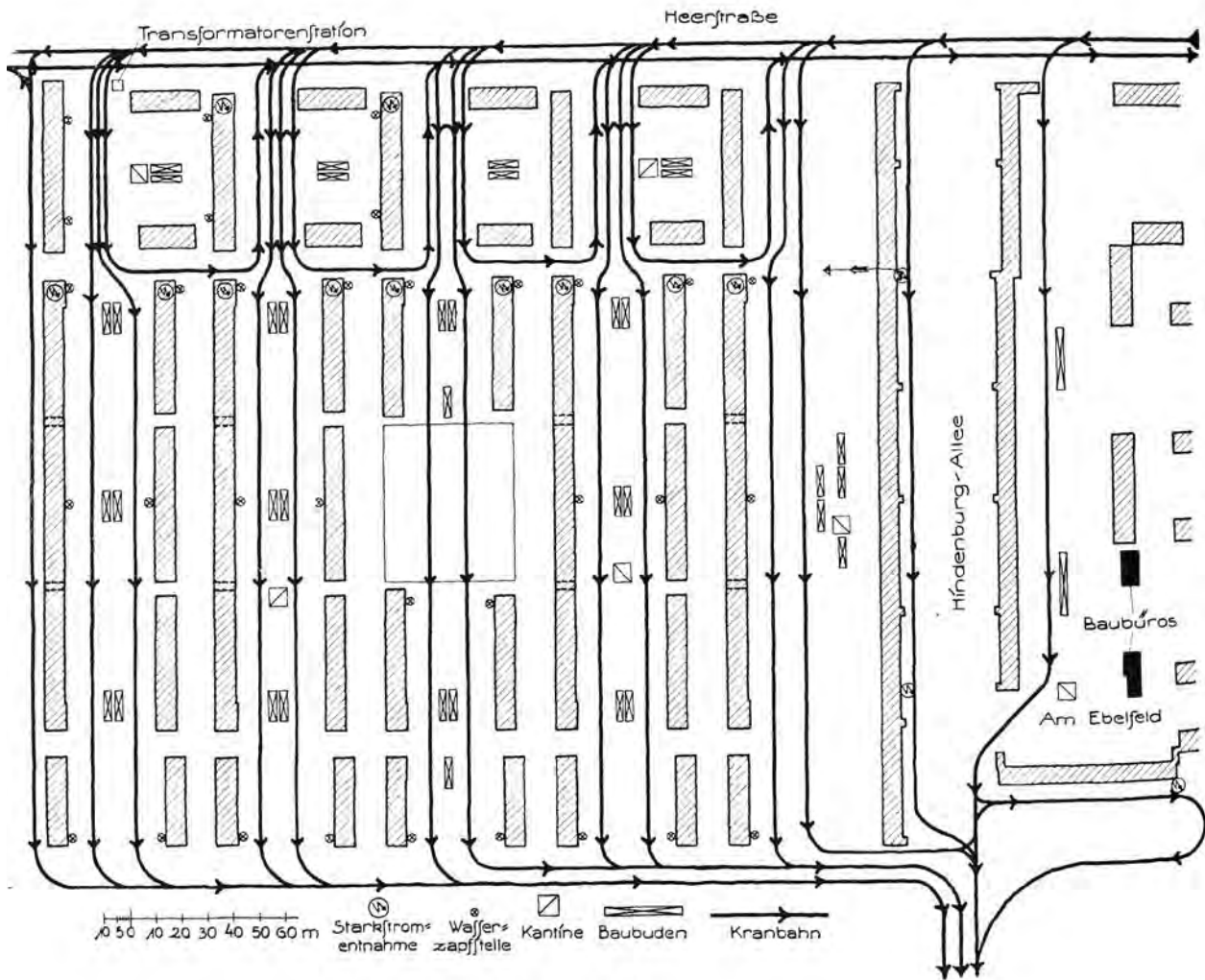


Bild 93.

Baustellenbetriebsplan für die Siedlung Frankfurt—Praunheim, Ausbau III, 1928/29.

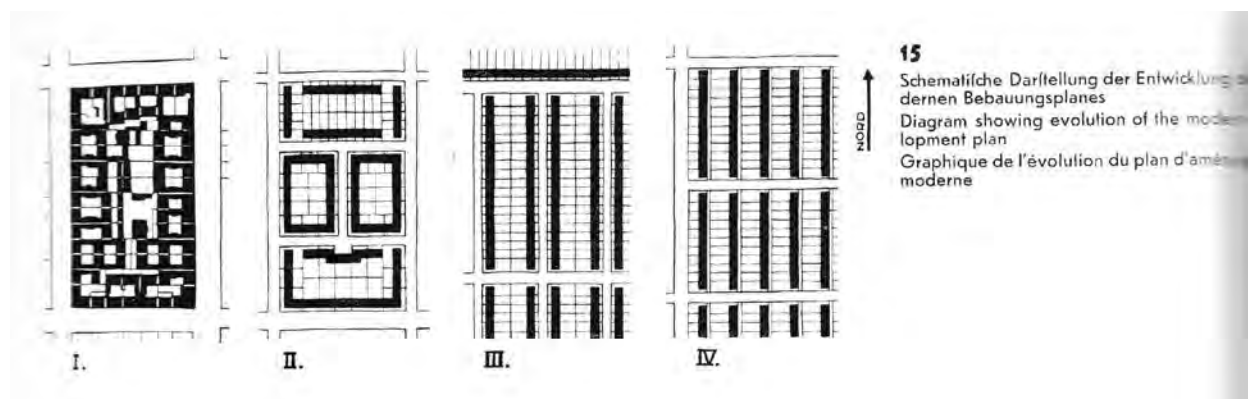
Fig. 221. Plates from RFG report showing Phasing of Praunheim (top) and the “building management plant” of Phase III, including routing of materials and equipment (bottom).

Source: *RFG Sonderheft* Nr. 4, no. Gruppe IV, NR. 2 (April 1929). 94.



EINFAMILIENWOHNHAUS IN PLATTENBAU
TYP 8, Erdgeschoss

Fig. 222. Plans of Type 8, Praunheim Phase I (left), plans of Westhausen Type, as a duplex (middle) and plans of Westhausen, converted into a single-family row-house (right).
Sources: *Das Neue Frankfurt 8* (August 1928). 130; Dreyse, DW. *Ernst May Housing Estates: Architectural Guide to Eight New Frankfurt Estates 1926-1930*. Translated by Patricia Grossman. Frankfurt: Fricke, 1988 (1986).



15
Schematische Darstellung der Entwicklung moderner Bebauungspläne
Diagram showing evolution of the modern development plan
Graphique de l'évolution du plan d'aménagement moderne

Fig. 223. Plate from *Das Neue Frankfurt* "showing evolution of modern development plan".
Source: *Das Neue Frankfurt 3* (March 1930). 34.

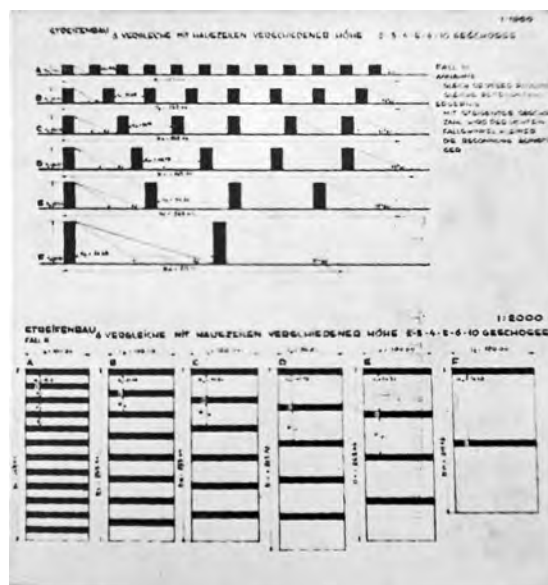
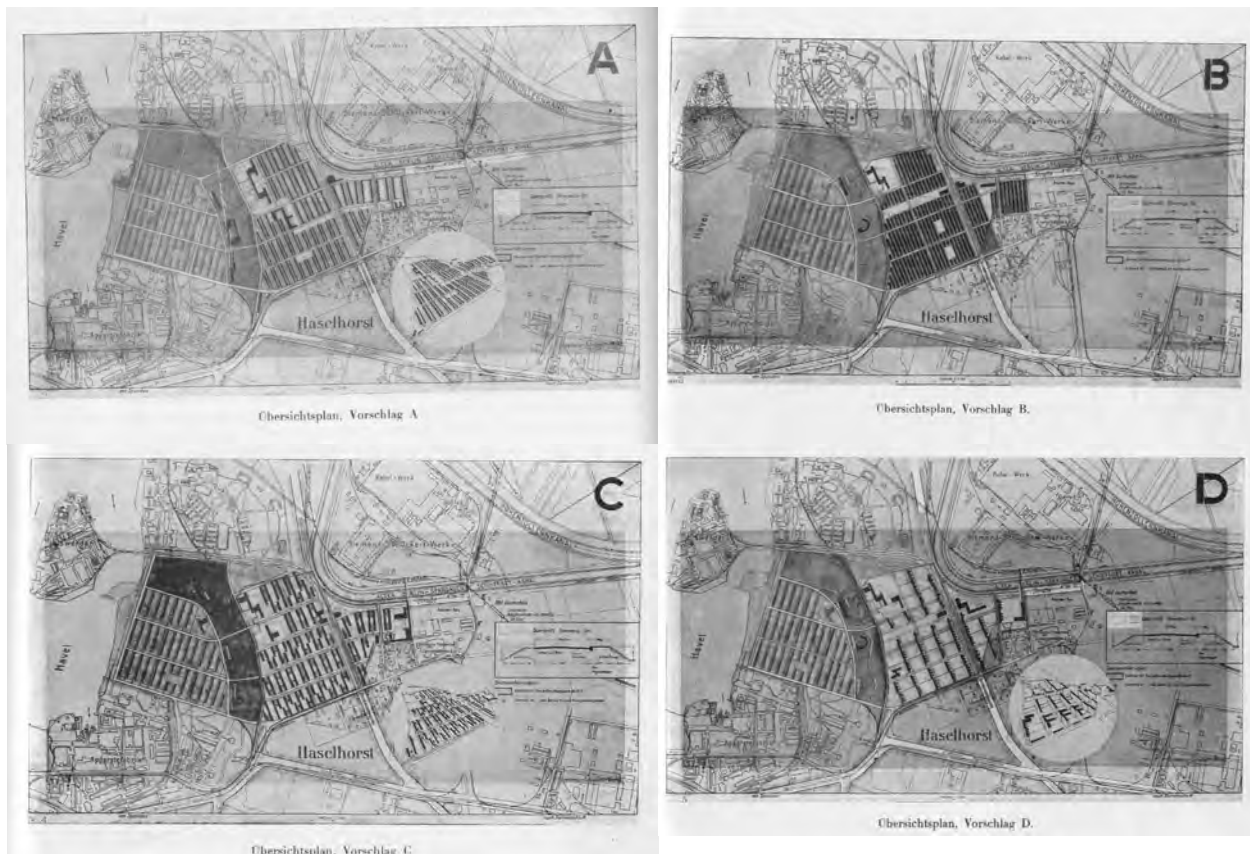


Fig. 224. Walter Gropius, four settlement design schemes for the Spandau-Haselhorst research settlement competition, 1929 (top) and plate from *Das Neue Frankfurt* showing a range of densities for settlement-building, based on the Spandau proposal (bottom). Compare diagrams to Westhausen scheme, Fig. 187. Sources: "Reichswettbewerb Zur Erlangung Von Vorentwürfen Für Die Aufteilung Und Bebauung Der Geländes Der Forschungssiedlung in Spandau-Haselhorst." *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen Sonderheft* Nr. 3, no. Gruppe II 1 (February 1929); Gropius, Walter. "Flach-, Mittel-, Oder Hochbau?". *Das Neue Frankfurt* 5, no. 2 (February 1930): 22-30.



Fig. 225. Photographs of Westhausen Settlement (2012), showing the relationship of individual allotment gardens and pedestrian paths (top) and a view looking west over the "landform" of the row-house units, as seen from the gallery circulation of the multi-unit slabs, on the eastern edge of the settlement (bottom).
Source: Author.

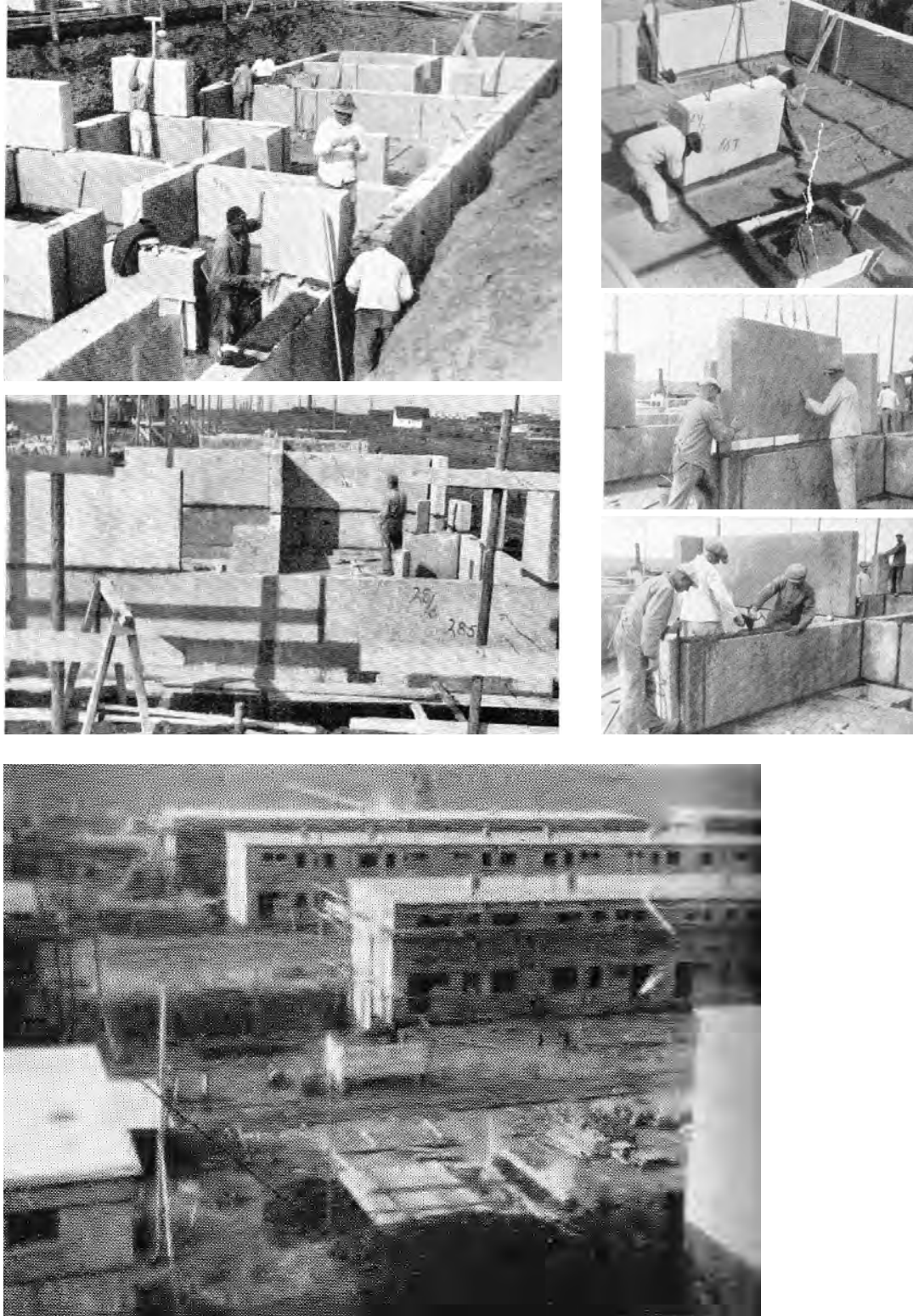


Fig. 226. Photographs and progress photos of panel assembly, with new lost tile floors visible (top) and a photograph of the organization of the construction site, taken from the same view as Figure 225 (bottom).
Source: *Das Neue Frankfurt* 3 (March 1930). 43, 56, 57.

Conclusion: Figures

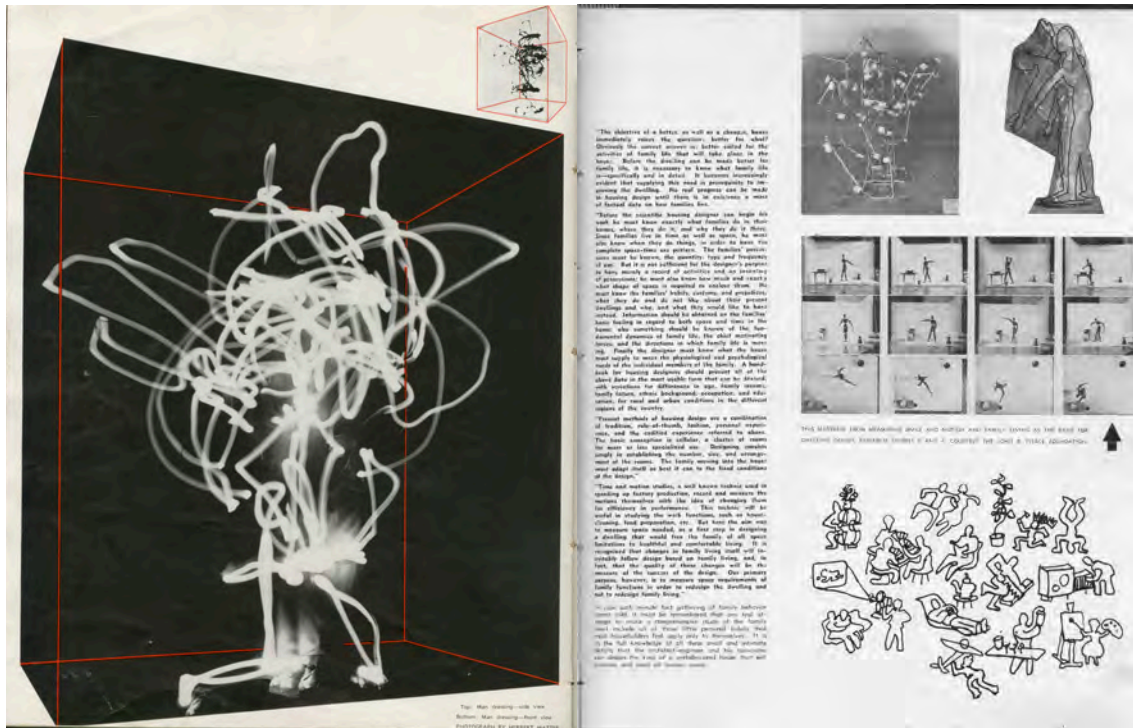


Fig. 227. Spread from Eames, "What is a house?," showing a cyclegraphic study of a man dressing by Herbert Matter (left), motion studies conducted by the John B. Pierce Foundation (top right) and sketches by Charles Eames (bottom right).

Source: Charles Eames, John Etanza. "What Is a House?". *Art and Architecture* Prefabrication (July 1944).



Fig. 228. Skidmore Owing and Merrill. Model used to plan the organization of the construction and occupation of the offices of Connecticut General Life Insurance Company headquarters (1954–1957).

Source: Krinsky, Carol Herselle. *Gordon Bunshaft of Skidmore, Owings & Merrill*. Cambridge: The MIT Press, 1988.

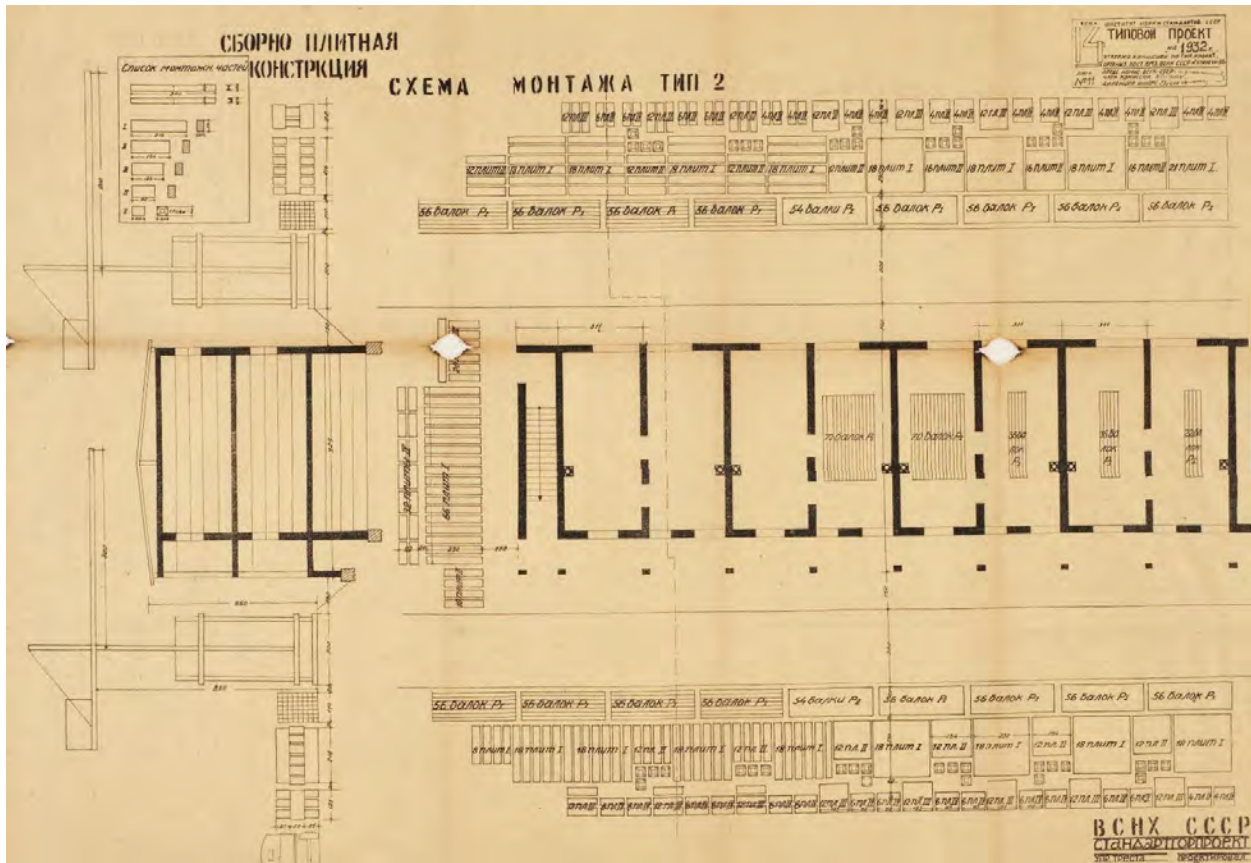


Fig. 229. Ernst May, May Brigade. Type Project 14 perspective view of assembly (top) and plan of assembly, showing the positions of the panels (bottom), 1932.
 Source: CCA. DR 1983:0899, DR 1983:0898

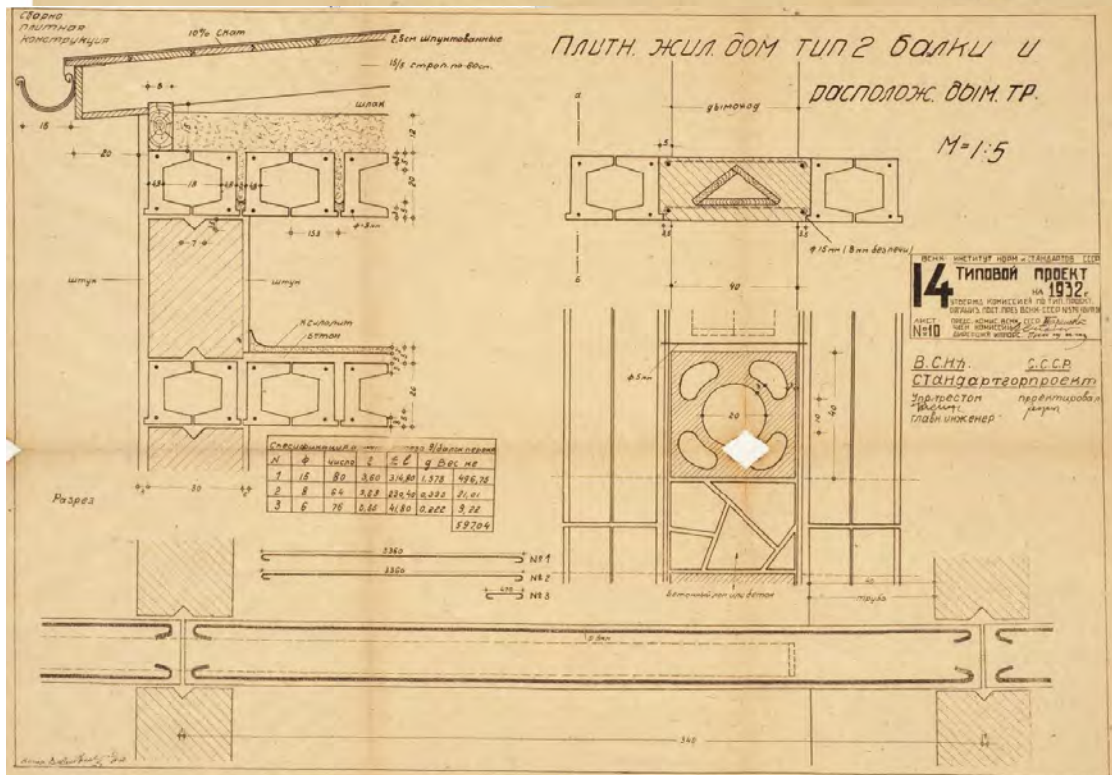
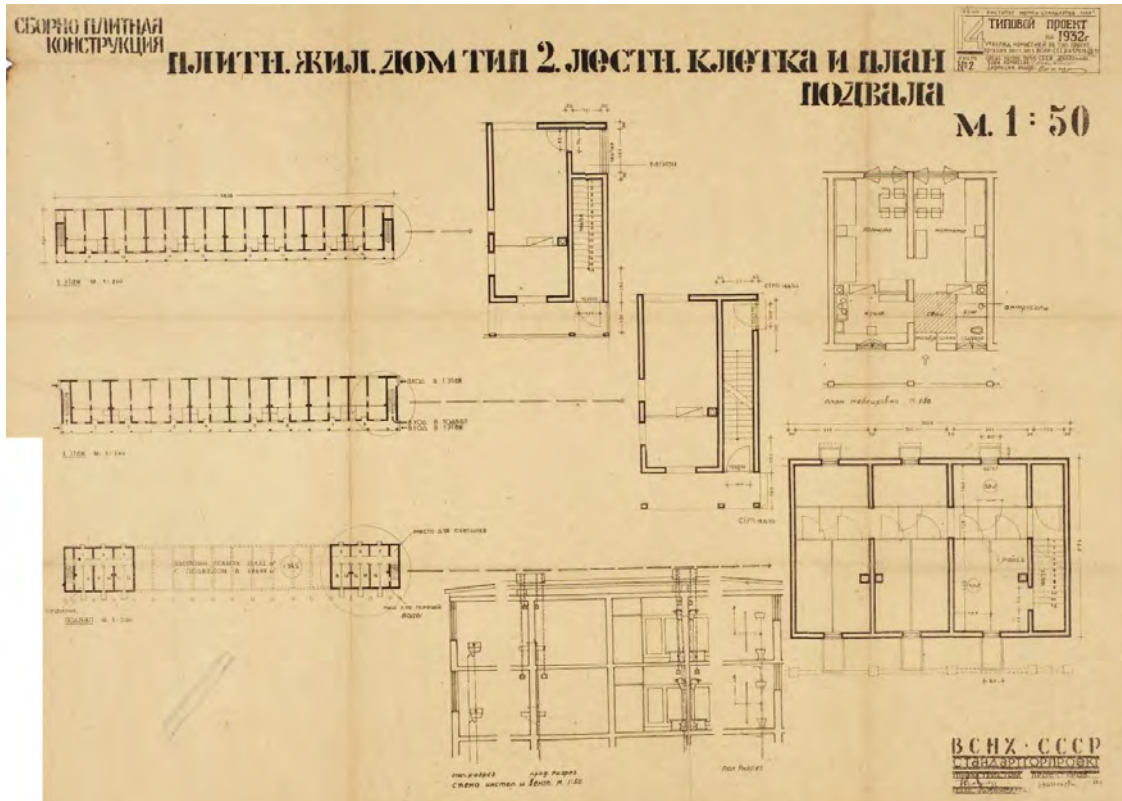
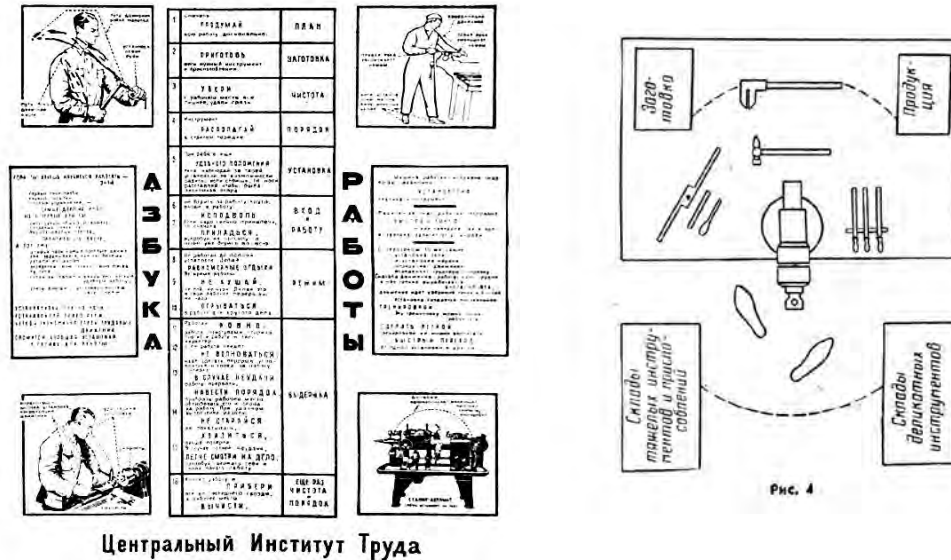


Fig. 230. Ernst May, May Brigade. Type Project 14 plan projections showing the variability of occupation (top) and construction details showing use of prefabricated panels, rapid beams and wooden roof construction (bottom).

Source: CCA. DR 1983:0889, DR 1983:0897

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Fig. 231. Cover of Gastev's *Kak Nado Rabotat* (How we should work) showing the "alphabet of work", at the center, and diagrams of various 'cyclegraphs' of work, to the left and the right (left) and plate showing a workstation, informed by motion study (right).

Source: Gastev, Aleksei. *Kako Nado Rabotat: Prakticheskoye Vvedeniye V Nauku Organizatsii Truda* [How We Should Work. A Practical Introduction to Scientific Management]. Moscow: TsIT, 1966.

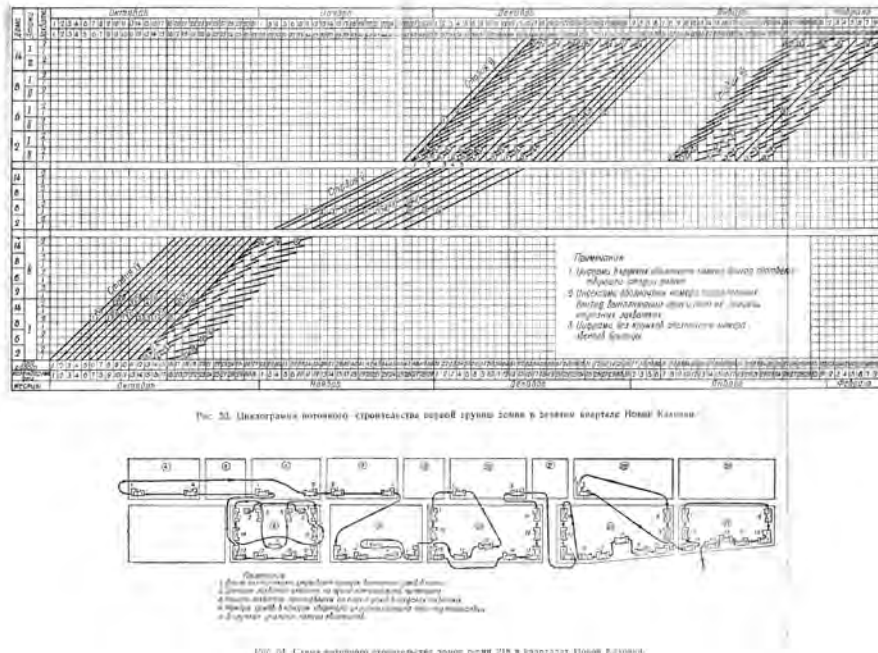


Fig. 232. Plate from Klindukh's *The Calculation of the Routed Building of Serialized Housing* showing a cycle-graph of routed building of the first group of housing units (top) and a scheme of routed building of Series 218 houses (bottom), part of the New Kahovka settlement, Ukraine, 1956-58.

Source: Klindukh, Aleksandr Mikhaylovich. *Raschet Potochnogo Stroitel'stva Seriynykh Zhilykh Domov* [The Calculation of the Routed Building of Serialized Housing]. Kiev: Ukrainian SSR Publishing House of Literature on Building and Architecture, 1959. 166.



Fig. 235. Assembly of JU 61 System, showing the universal floor and wall panels and a system of reusable wooden centering forms, 1963.
Source: Private Archive, Bogdan Budimirov.



Fig. 236. The JU 61 aluminum "membrane" (left) and the assembly of the JU 61 façade (right), 1963.
Source: Private Archive, Bogdan Budimirov.

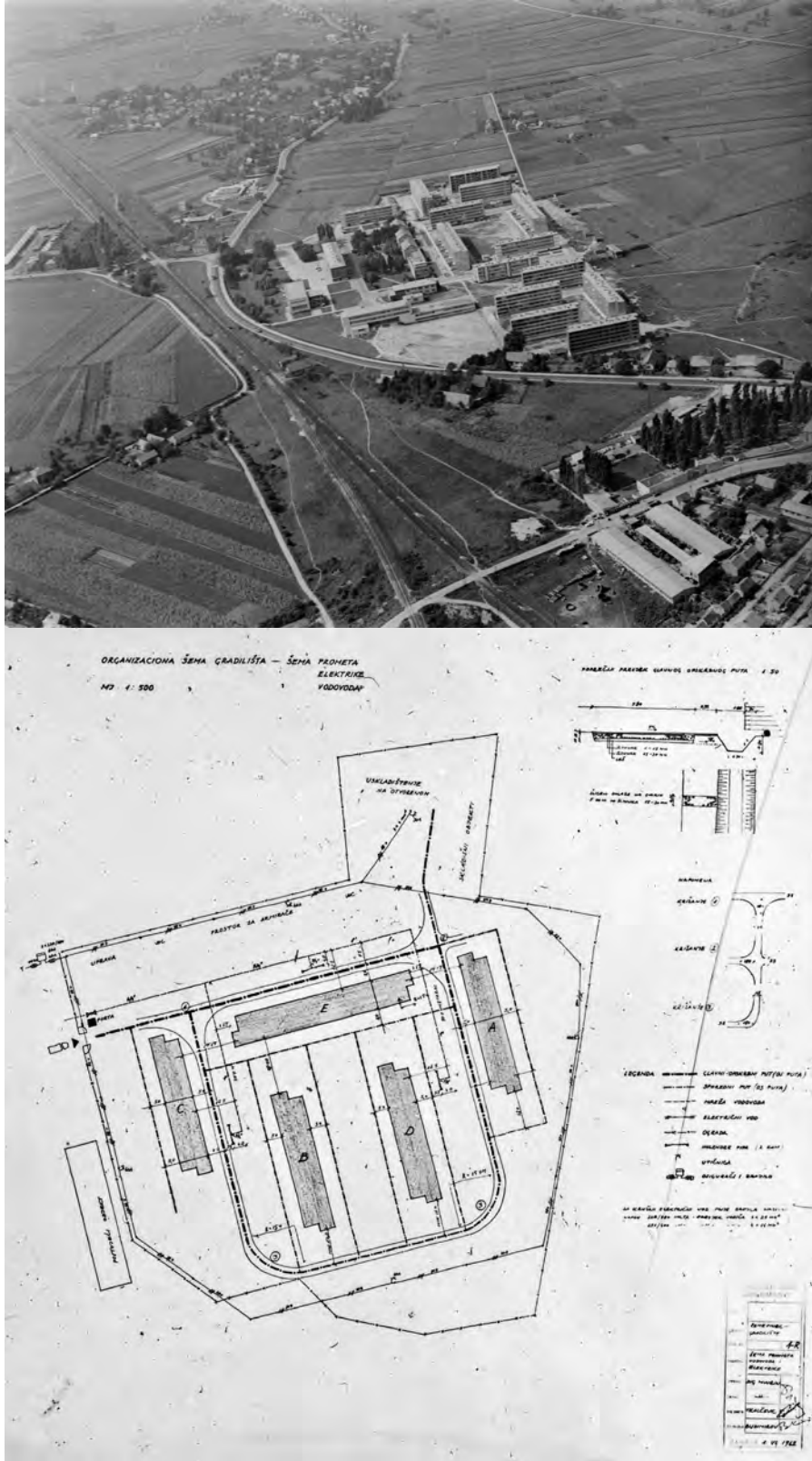


Fig. 237. Experimental building site, Settlement of the February Martyrs, Remetinec, Zagreb, 1963 (top) and Bogdan Budimirov, Jugomont Technical Department. Scheme of Routing, Remetinec, May 1, 1962. Source: Private Archive, Bogdan Budimirov.

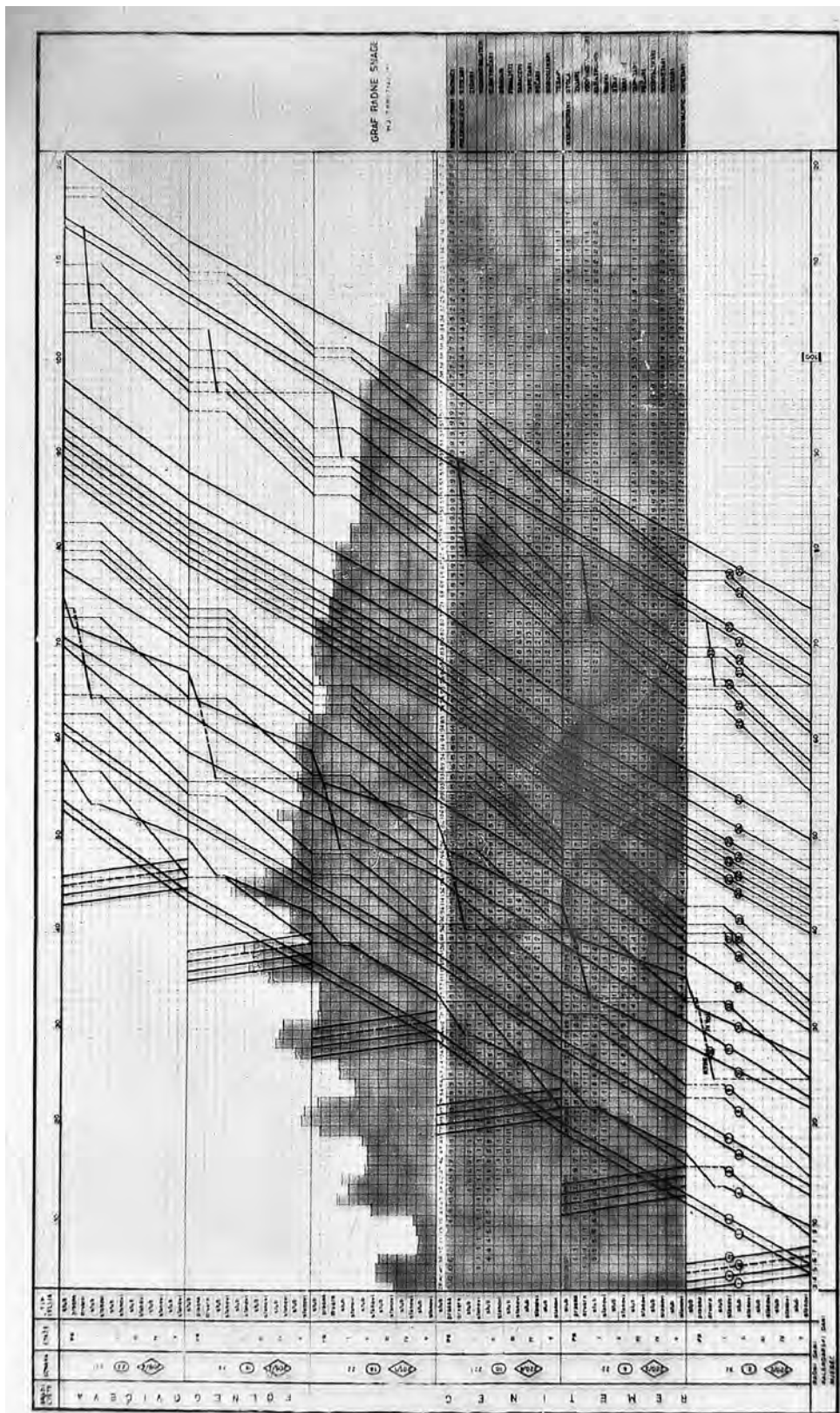


Fig. 238. Bogdan Budimirov, Jugomont Technical Department. Cyclegraphic plan (ciklogram) and record of two housing blocks at Folnegoviceva Settlement four housing blocks at Remetinec Settlement, 1963. Source: Private Archive, Bogdan Budimirov.

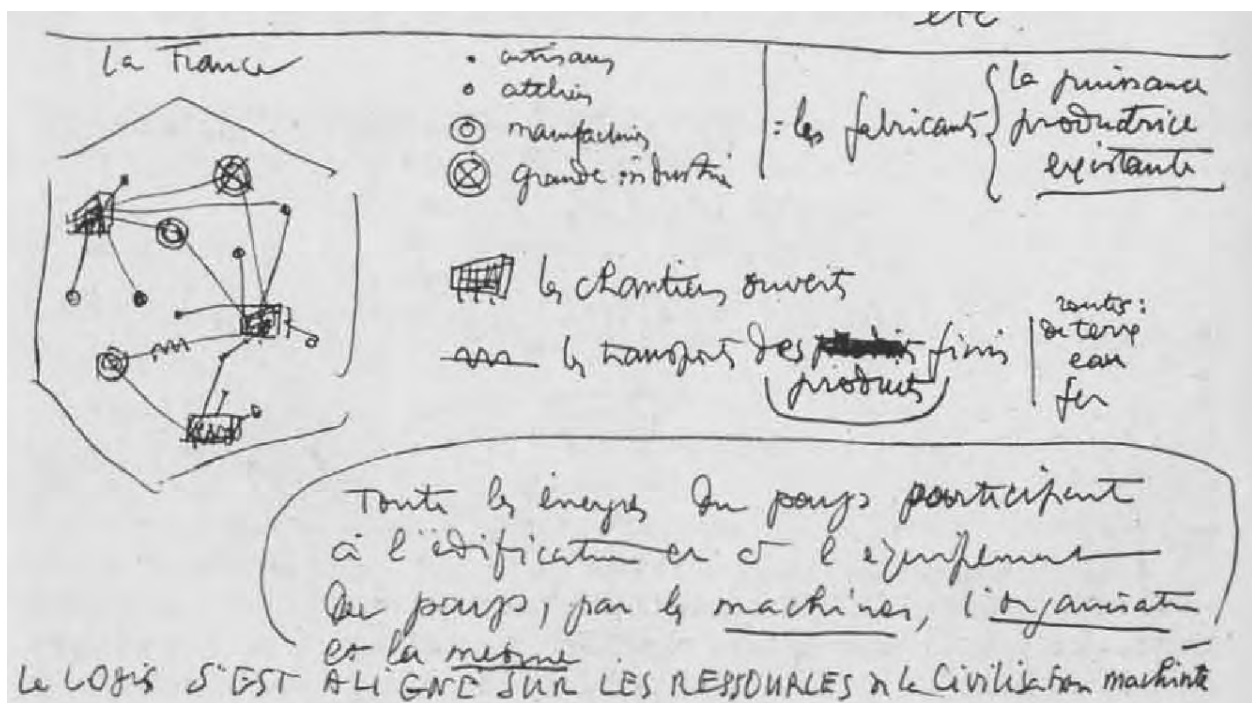
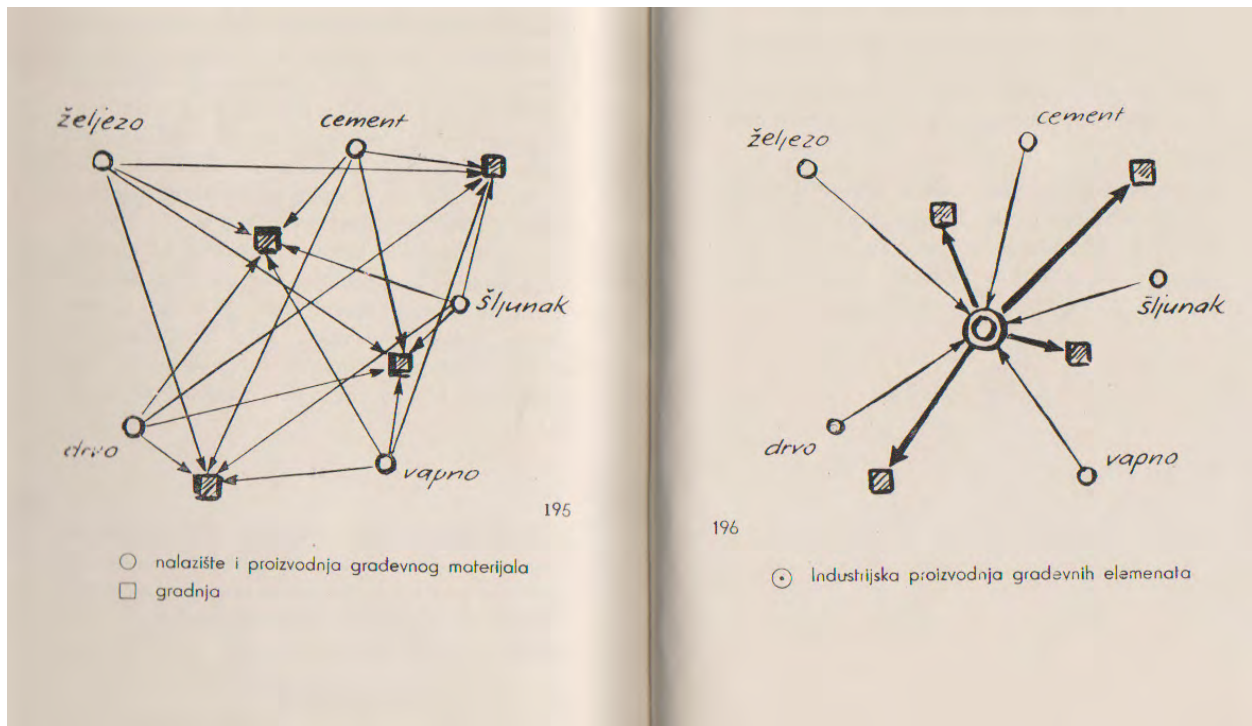


Fig. 239. Plates from Strizic, *Architectural Projection I*, showing the territorial organization of conventional (left) and industrialized building (right), indicating the locations of raw materials, as circles, sites of manufacture, as a double circle, and building sites, as black squares (top) and a plate from Le Corbusier's *The Marseilles Block*, showing a similar diagram of the logic of the Unité within the context of all of France (bottom). Source: Strizic, Zdenko. *Arhitektonsko Projektiranje I*. Zagreb: University of Zagreb, 1952; Corbusier, Le. *The Marseilles Block* [L'unité d'habitation de Marseille]. Translated by Geoffrey Sainsbury. London: The Harvill Press, 1953 (1950).

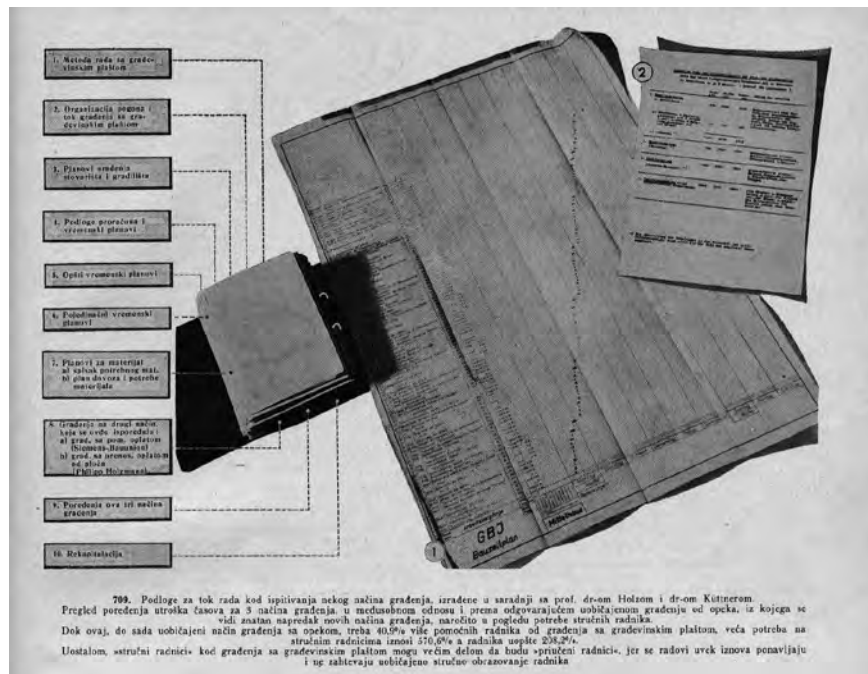
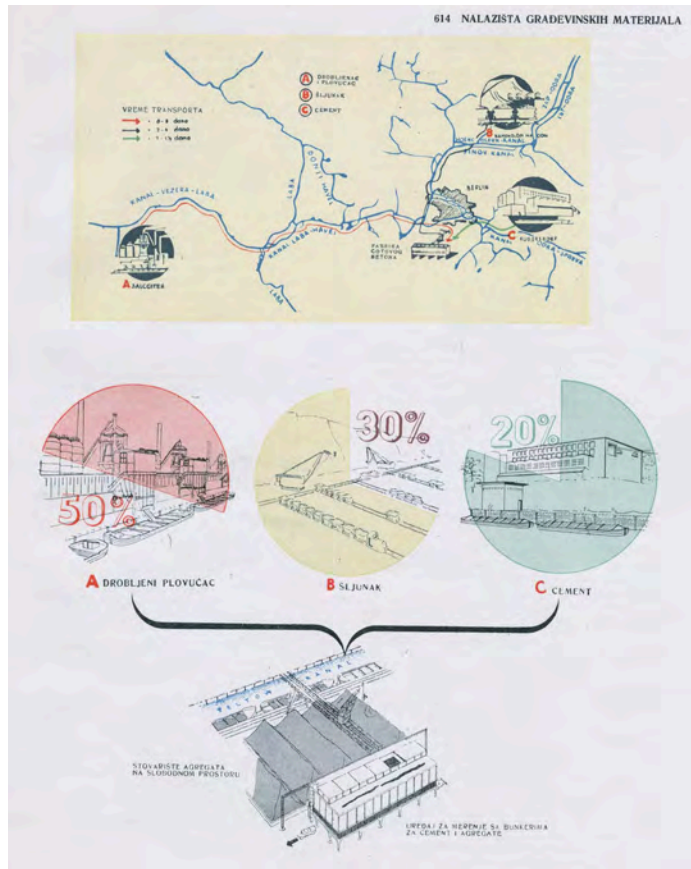


Fig. 240. Plates from Neufert's *Bauordnungslehre* (translated into Serbo-Croatian), showing the organization of material and product routing, around Berlin (top) and the use of a *bauzeitplan* and its relationship to instruction cards and DI-Norms (bottom).

Source: Neufert, Ernst. *Pravila Gradevinarstva* [Bauordnungslehre]. Translated by Vladimir Potocnjak. Belgrade: Gradevinska Knjiga, 1952. 1943.

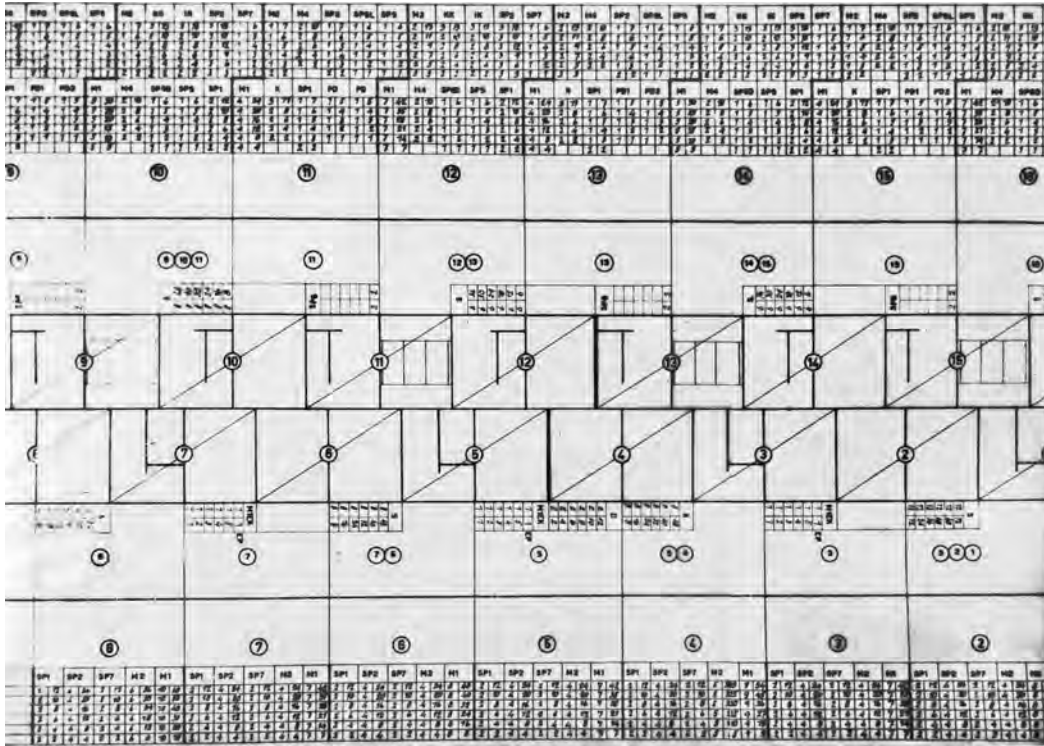


Fig. 241. Drawing showing locations of JU 61 panels in their delivered and assembled positions, 1961 (top) and photograph of the application of this projection system at Borongaj Settlement, Zagreb, later 1962 (bottom).

Source: Private Archive, Bogdan Budimirov, photograph published in "Prefabrication En Yugoslavie Procède JU 61." *l'architecture d'au jour'd'hui* 104, no. Habitat (1962): 49.

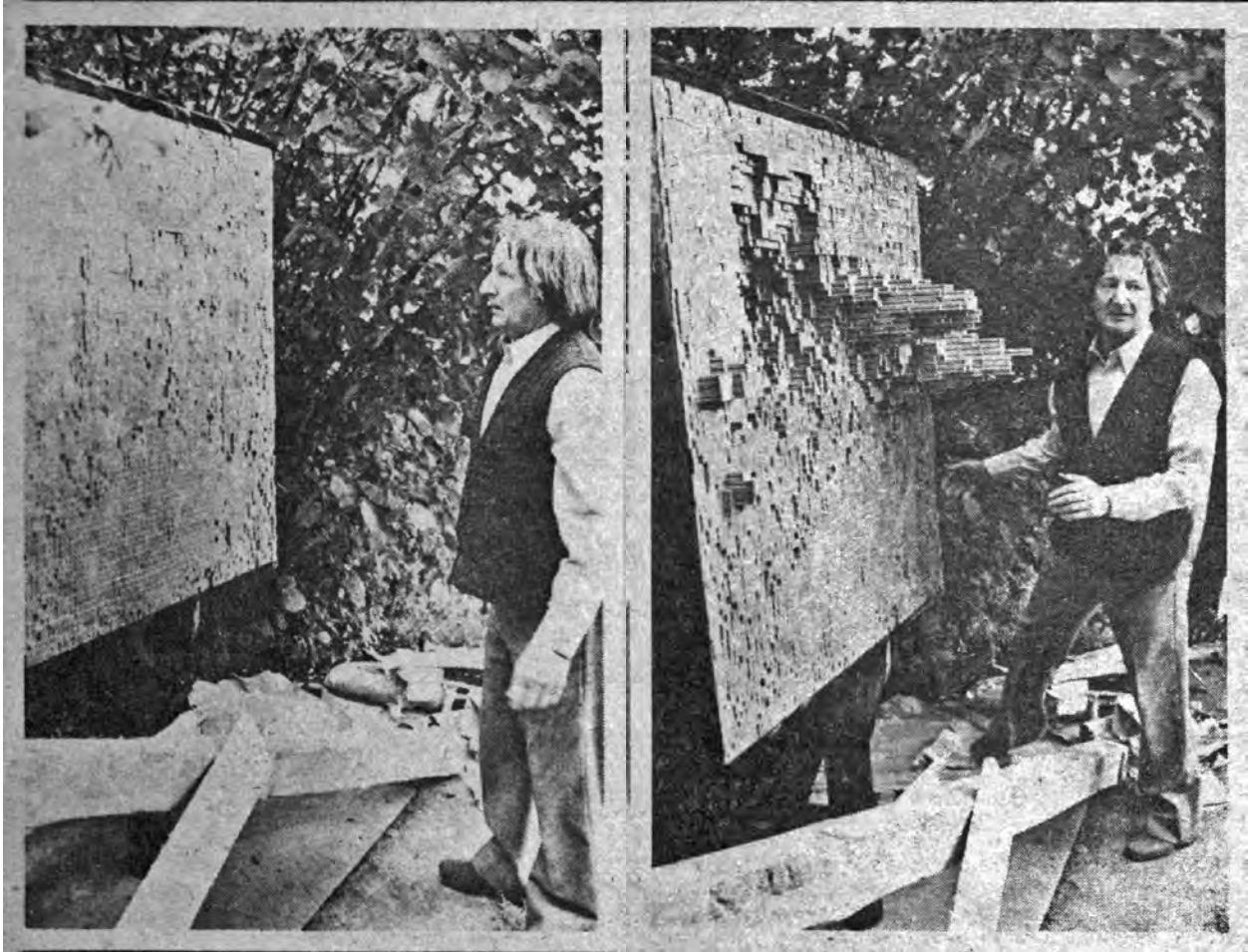


Fig. 242. Series of photographs showing Vjenceslav Richter's interaction with his Reliefmeter model (1963-68) of a self-managed settlement (synthurbanism/cyclerat), in 1971.
Source: *Vjesnik*, Zagreb, 1971. 12-13.

Archives:

FLGA: Frank and Lillian Gilbreth Library of Management Research and Professional papers, 1845-1959, Purdue University Libraries, Archives and Special Collections, West Lafayette, Indiana.

FLC: Fondation Le Corbusier, Paris, France.

BRGA: Harvard Art Museum/Busch-Reisinger Museum, Gift of Walter and Ise Gropius, Harvard University, Cambridge, MA.

Harvard Art Museums/Fogg Museum, Transfer from the Carpenter Center for the Visual Arts, Social Museum, Harvard University, Cambridge, MA.

Loeb Library, Harvard Design School, Harvard University, Cambridge, MA.

DAM: Deutsches Architektur Museum, Archiv, Plan- und Modellsammlung, Ernst May Archive, Frankfurt, Germany.

CCA: Canadian Centre for Architecture, Ernst May Archive, Montreal, Canada.

Croatian State Archives, Building Permits, Zagreb, Croatia.

Museum of Contemporary Art, Zagreb, Vjenceslav Richter Archive, Zagreb, Croatia.

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