Transforming the Invisible Hand: Redefining the Machine-Made House

Paul J. Armstrong
University of Illinois Urbana-Champaign

Style is the coincidence of a structure with the conditions of its origins.
--Gottfried Semper

Abstract

This paper considers the role of prefabrication and its impact on the architectural imagination and sustainable design of the modern house. From its inception, the modern house was to be economical, functionally efficient, and conducive to modern living. The modern architects embraced the machine aesthetic of industrial materials and production techniques as the harbingers of a new era characterized by the "aesthetic of the engineer," which is evident in prefabricated architecture today.

Fig. 1. Aluminum wall panels construction, Vultex Aircraft Factory, CA, ca. 1946.

Through an investigation of prototypical industrial houses, this paper will show how modernist visions of the future have predicted and paved the way for advances in design, program, and technology, or where those visions have failed to materialize. Finally, it will speculate on new directions in the machine analogy and how architects today are redefining the sustainable house of tomorrow and restoring imagination to the activity of dwelling.

Introduction

The movement toward creating affordable houses in the U.S. began in the late 19th century with the introduction of pattern books. Sears and Roebuck and Montgomery Ward offered kit-built homes in their respective catalogues, which could be shipped anywhere in the continental U.S. They were followed by the Aladdin Readi-Cut House (1906) and the all-steel Lustron House (1948). While all were not successful, they introduced a more efficient and "modern" way of building and marketing houses.

The prototypical modern houses of the early 20th century established the social, political, and philosophical differences that produced both the canonic *machine à habiter* as well as the machine-made house. While both were rooted in modern ideology, they manifested themselves in fundamentally different ways. Wright's organic Usonian Houses, Le Corbusier's machine-like Citrohan House, and Buckminster Fuller's aircraft-inspired Dymaxion and Wichita Houses represent approaches that synthesized modern principles with craft, economy, and machine production (Fig. 1).

The Utopian vision of the prefabricated house continues today, but with sustainability as a key criterion. Willis suggests that designing sustainably is more than minimizing the negative effects of building on the planet's ecosystem. A truly sustainable architecture requires that the making and maintenance of buildings must serve to increase their, as well as our, human dignity. The goal of transforming ordinary industrial materials and techniques into extraordinary buildings was a hallmark of the Case Study House program. Charles and Ray Eames, Pierre Koenig, and Craig Elwood experimented with inexpensive, off-the-shelf steel components to create simple yet extraordinary dwellings. This tradition continues today. Heikkenen-Kommenen's

"Touch" house, Adam Kalkin's Quik Build House, and Oskar Leo Kaufman's FRED modular house building system demonstrate that prefabricated houses represent "the most interesting and innovative architectural designs today."[1]

Dwelling and Prefabrication

Daniel Willis notes that dwelling is an activity that unites the physical and the imaginative. The appeal of home ownership and dwelling can be diminished if there is not a commensurate investment in the activity of building or at least maintaining a home by the owner.[2] This suggests that building is a participatory process involving the owner at the earliest stages of the process to develop a contingent "sweat equity" which continues with habitation. If we concur with Willis, building and habitation are processes that are inefficient because dwelling is a "delayed imaginative condition" that cannot be commoditized. This conforms to Heidegger's view that building as craft should somehow be resistant to machine production lest the meaning of dwelling be compromised. Willis adds that the "invisible hand" of the machine imposes an aesthetic as well as a predictable outcome, which also diminishes imaginative dwelling. We cannot rule out the machine entirely, however, if we are to be truly modern.

The meaning of "dwelling" is the point at issue when we consider prefabrication. As Gilbert Herbert notes, when we build a home—the function of which is to conserve, to protect privacy, family life, and cultural and social values, traditions—"the most conservative forces are in operation."[3] The perception of the factory-made house as a temporary solution only has been shared by the public and the manufacturers of these buildings. The notion that architecture should be permanent, enduring, and timeless mitigates against the use of industrial building materials—wooden panels, corrugated iron and steel sheets, concrete panels, and the like—and the placement of "temporary" buildings within the traditional urban fabric. Prior to the twentieth century, the use of new technology was politely concealed from public view by eclectic architectural screens.

According to Colin Davies, the relationship between architecture and prefabrication has always been problematic. Up until recently, many architects have found it hard to come to terms with the idea that products of their art might be made in a factory. As Willis points out, architecture was always allied with craft and thought of as timeless. "When we build," said John Ruskin, "let us think we build forever." The failure of the early Modernists to put the prefabricated house at the center of their program of reform was not "a proof that buildings do not lend themselves to factory production" but that they have been "beyond the pale of the architectural field."[4]

The crisis imposed by World War I changed our understanding of modern architecture and "normality," especially in regard to dwelling. European architects embraced prefabrication as a time- and cost-effective method of building, whereas in America it was still a novel idea.[5] By 1920 in Great Britain, for example, the Ministry of Works had approved some 110 systems of construction, of which perhaps 12 involved some degree of prefabrication.[6] Le Corbusier was an early and fervent proponent for prefabrication. His Dom-Ino House of 1914 presented a new type of skeletal-framework construction of reinforced concrete that formed the floors, supports, and stairs of a building and eliminated the need for load-bearing walls. In his essay "Mass Production Houses" (1919) he drew a moral analogy between healthful living and the "House-Machine."[7] And Walter Gropius, founder of the Bauhaus, had called for the industrialization of housing as early as 1910 in an effort to create a "new architecture for a new age." In 1923 Gropius and Adolf Meyer developed "Building Blocks," a system of standardized flat-roofed housing.

In the U.S., pattern books published in the late-nineteenth century featuring designs by architects committed to affordable homes such as Andrew Jackson Downey became available to the middle class. Later Sears, Montgomery Ward, Aladdin Houses, and other companies offered kit-built homes which could be ordered "as simple…as any other household product."[8]

The housing industry had followed the model of the automobile industry in order to develop factory processes for construction. The Great Depression fostered a climate in which factory-built homes seemed the only practical option. In 1927, Robert Tappan introduced a steel-framed house and Buckminster Fuller introduced a prototype for his Dymaxion House. But it was not until 1932 and Howard T. Fisher's General Houses Corporation that the

assembly-line production of houses in the U.S. became a reality. Fisher's company acted as an assembler of parts which were ordered to its own specifications that were produced by building-component suppliers such as General Electric, the Pittsburgh Plate Glass Company, and Pullman Car and Manufacturing. Seen as the General Motors of the building industry, General Houses produced affordable houses ranging from $3,000 to $4,500 dollars.[9]

Fig. 2. House of Tomorrow (left) and Crystal House (right), George Fred Keck, 1933.

Steel was increasingly becoming an integral part of the housing industry in the 1930s. A number of steel-prototype houses were presented at the Chicago World's Fair in 1933. George Fred Keck's House of Tomorrow and Crystal House were both displayed at the fair's Century of Progress Exhibition (Fig. 2). Each exhibition house was supported by a steel framework and steel-deck floor system. A standout at the exhibition, Keck's House of Tomorrow was a three-story, twelve-sided structure built on a steel frame. It featured glass walls and even an airplane hangar on its ground floor. It had central heating and air conditioning, window-shading devices to control the level of incoming light, and it featured an innovative prefabricated structural frame, which allowed it to be erected in three days.[10] But its bold constructivist aesthetic and its less-than-prime location on the fairgrounds got in the way of its success. The house was sold for scrap at the end of the season.

Walter Gropius and Konrad Wachsmann collaborated on an all-steel prefabricated Package House and formed the General Panel Corporation in 1942. Unlike its predecessors, the Packaged House offered a completely flexible factory-produced system of "standardized parts which should be interchangeable for use in different types of houses."[11] Despite sound financial backing and production support from the aircraft industry, their venture proved to be unsuccessful.

Herbert relates the problems in industrialized housing in the U.S. to a lack of government support as well as private-sector enthusiasm. In Europe after World War II the main thrust of construction was in state-supported high-density housing developments, employing substantial construction systems, mainly in reinforced concrete. In the U.S. in the 1950s and 1960s, there was no such massive state intervention in the housing process, no assured continuous market, and no large-scale development of comprehensive building systems. Nor did later government encouragement succeed in generating practical, economical, and viable industrialized building systems. However, The General Panel Corporation failed, in part, because Wachsmann had little interest in the development of prefabricated dwelling modules or an economical solution to the housing problem. Rather, he was drawn philosophically and aesthetically "to the elegant exploitation of advanced technology" and "the finesse of machine production."[12]

Industrial Materials and CSH

Willis recognizes that craft-based technologies are, by definition, inefficient because, in eschewing the machine, they use inefficient methods of production. Furthermore, the machine aesthetic, in its quest for perfection, subverts the imperfections of hand craftsmanship. After World War II architects in the U.S. began experimenting with materials and fabrication methods that incorporated craft-based strategies with industrial materials and production methods. Frank Lloyd Wright pursued the Usonian—a lower-cost single-family house prototype based on his organic principles. And in California, John Entenza synthesized the visions of modern living espoused in *Arts & Architecture* through the Case Study Houses.

Although he considered himself a modern architect, Frank Lloyd Wright never fully embraced the machine aesthetic. In his adherence to his organic principles, Wright used technology as a means but not an end—at least not in the aesthetic sense of the Bauhaus. As far back as the beginning of the twentieth century, Wright had troubled himself with the challenge of creating affordable housing. Although Wright's best-known effort was his Usonian prefabricated houses, less well-known were some of his last prefabricated kit homes created in 1957 for Marshall Erdman, a design-savvy owner of a construction company Marshall Erdman & Associates.[13]

Wright persuaded Erdman that he could create affordable, well-designed prefabricated kit houses for $15,000, half the cost of Erdman's then-existing "U-Form-It" kit homes. The first Erdman prefabs were built in 1955 and based on three designs. The most interesting was Erdman Prefab Design #2, a compact light-filled prefab kit constructed in 1957 in Madison, Wisconsin. Its square shape contained a double-height living room flanked by a perpendicular wall of rectangular wood-framed ribbon windows that bathed the house in natural light and made for an effective passive solar system. The windows also engaged with the surrounding landscape maintaining Wright's organic, environmentally friendly principles. Standardized panels of mahogany lined the interior, and the roofline was capped with Wright's decorative molded blocks, which added visual texture and richness to the home. The house arrived as a kit of parts complete with components from kitchen cabinets and windows to exterior walls—everything needed to complete the house save for the foundation, heating and plumbing fixtures, electrical wiring, and paint, all of which the buyer had to supply. Despite the prestige and innovation Wright brought to the project, the Erdman prefab homes proved simply too expensive to produce and were never cost-effective enough to attract lower-income buyers.

Fig. 3. CSH #8, Pacific Palisades, CA, Charles and Ray Eames, 1949.

Industrial materials were used extensively in the ground-breaking designs of the Case Study Houses of the 1940s and 1950s. Charles and Ray Eames created their iconic Case Study House #8 (Fig. 3) using an innovative home building system that relied on a standard kit of parts. The Eameses envisioned it as "a living laboratory" that presented a bold development in off-the-shelf housing "in which the creative possibilities inherent in industrial materials and components were exuberantly explored in the context of the practical realities of everyday life."[14] It demonstrated that standardized factory-made components need not result in sterile, endlessly replicated static designs, but instead could result in a flexible kit of parts that could allow architects to more playfully and efficiently explore an endless combination of creative housing options.

The Case Study Houses were initiated by John Entenza, editor of *Arts & Architecture*. He invited eight architects and designers to "propose a house that offers the best conditions of life to American middle class family."[15] The solutions and materials could draw on old sources or from new innovation, but must be buildable at low cost while grabbing "hold of the present and future, tame it, and understand it."[16]

The Eames House was soon followed by others that incorporated industrial materials in creative ways. The glass and steel Case Study Houses designed by Craig Elwood and Pierre Koenig personify the sublime period of the CSH prefigured by Charles Eames and Eero Saarinen. Ellwood designed three Case Study Houses—Nos. 16, 17, and 18—between 1952 and 1958. All three houses were low-slung, flat-roofed, single-story structures of steel and glass. As a former engineer, Elwood appreciated prefabricated technologies and left the steel frames exposed. He was among the first American architects to unabashedly embrace new materials for the mass production of housing in "our expanding machine economy." His reasoning was pragmatic due to "the increasing cost of labor and the growing lack of craftsmen."[17]

Set in the hills overlooking Los Angeles, Koenig's Case Study House #21 (the Bailey House) was created from manufactured steel and glass industrial components. It meticulously integrated detailing such as a brick patio and cooling water pools "to create a rich tapestry of sight, sound, and texture, offsetting the muted simplicity of the architecture itself."[18] Like Elwood, Koenig intended his houses to be put into production.[19]

Building a Better m-[h]ouse

While the Case Study Houses never made it into the mass market, they influenced a new generation of architects and home buyers to think differently about the single-family house and modern living. However, it was not the sleek Case Study prototypes that took off, but the more generic planned-community

paradigm and the mobile home parks that were opening at a rapid rate during the mid-1950s. While these developments introduced social and infrastructure problems that made them tawdry in comparison with their suburban counterparts, they nevertheless introduced affordable housing that could be manufactured cheaply in factories. The introduction in 1954 of Marshfield Homes' "Ten Wide" mobile home made industrial products fashionable alternatives to conventional construction. The Ten Wide was two-feet wider than a conventional eight-foot-wide mobile home conventional to the industry—which meant that it took up more room in the factory—but provided more interior space and privacy. Soon other designers, such as Raymond Lowey and Wright's Taliesen Studio, were commissioned to design modern mobile homes based on the aesthetics of the International Style and "Prairie-School" plans, and details.

Fig. 4. Zip-Up House, Richard Rogers, 1968.

Carl Koch, the founder of Techbuilt, developed a housing system that took advantage of prefab technology without sacrificing individuality. Distancing himself from the pitfalls of the Package House and the uniformity of prefabrication, he stressed that Techbuilt was not a package, "but a system of converging components that the builder and owner complete at their discretion."[20] While it was only a difference in semantics, Techbuilt achieved a great deal of success in the 1950s and 1960s.

In Britain during the 1960s, many of the country's most innovative architects devoted themselves to the task of creating affordable, well-designed mass housing that addressed social concerns and energy demands. Richard Rogers developed the Zip-Up enclosures in 1968, a series of inexpensive, low-maintenance shelters that offered a high degree of environmental control and a large range of design choices (Fig. 4). The Zip-Up system of construction utilized a snug-seam joint from Alcoa and could be built in a matter of weeks using standard components. Since there were no internal structural elements, it allowed maximum flexibility for demountable partitions and allowed the house to be extended out or up by adding or removing panels.[21]

Jennifer Siegal's Portable House "is a rethinking of the trailer park and all the stereotypes that go along with it." Initially, the notion of a trailer as "a self-sufficient community" appealed to her social sensibility as an architect but not to her sense of aesthetics. But her reservations about manufactured housing changed as she focused on various aspects of mobile housing. The 40 x 12 foot mobile structures are very compact but can be stacked for vertical expansion. They can also be attached to one another. Innovative materials include Polygal structural wall panels—ribbed sheets which use 80 percent less materials than conventional framing methods and excellent insulation—and Homosote interior siding made form recycled waste paper. The design also uses tankless water heaters to conserve energy and reduce water consumption.[22] The Portable House is not aimed at the luxury end of the housing market and it is not rooted to place, thus it "is a response to the way we live and work today."

Tim Pyne's m-house is a full kit home that can be ordered online that is designed to sit "lightly on the earth." The 1,000-square-foot house features a flat roof for economy as well as aesthetics and customized exterior finishes, with a choice of plain aluminum, printed aluminum, cedar strips or shingles, or painted tongue-and-groove wood. The house is virtually maintenance-free and built to last at least 50 years.[23] Technically a factory-built mobile home, it has a self-supporting steel structure and lives like a modern loft.

Fig. 5. Glide House, Lake Chelan, WA, Michelle Kaufmann Designs.

Not all prefabricated houses have to look industrial—especially within. The 1,344-square-foot, two-bedroom Glidehouse (Fig. 5) consists of two modules, each 14 feet wide by 48 feet long.[24] The length of a module is an industry standard determined by the maximum size that can be placed on a flatbed truck. The two modules are set in a staggered parallel, allowing for patio space adjacent to the rear bedroom and in front of the master bedroom. A storage wall runs the full length of the house dividing the modules into public and private uses, and provides for a streamlined modern appearance. The house gets its name from an uninterrupted series of sliding glass doors framing the front elevation. The exterior side and rear elevations are clad with Galvalume corrugate metal sheets, which impart a domesticated industrial appearance.

Heikkenen-Komonen's "Touch" House prototype is designed for Finland where over 90 percent of the single-family houses are prefabricated.[25] The architects' goal was to make a different, more modern option for young families that would be equally suitable for urban or suburban environments. The house's mono-pitch roof forms a foursquare compact envelope around a series of varied outdoor spaces. All rooms are arranged around a one-and-a-half-story, open living/dining/kitchen area and are illuminated from above by glazed portions of the roof.

Interchangeable parts and flexible planning have been making prefabricated houses more affordable and attractive to home buyers accustomed to the choices and energy-efficient features offered in the custom home market. The 2,600-square-foot Flatpak House, designed by Charlie Lazor, is made up of a flexible kit of parts, which includes eight-foot cement sections, wood panels, and large picture windows to create a flexible, harmonious design. It uses a concrete foundation consisting of insulated concrete panels that are precut complete with holes for stud walls. Douglas fir exterior panels are placed on top of the concrete wall and capped by a slim band of clerestory windows. Floor-to-ceiling windows open the opposite elevation to views. The 20-foot by 70-foot structure is capped by a well-insulated energy-efficient metal roof. Like the Techbuilt Houses which afforded flexibility through a "plug-in" kit-of-parts, the Flatpak's panelized building system allows owners to customize their house. Depending upon the site and extras, it may cost anywhere from $190 to $200 per square foot and take six months to build.[26]

More recently, variations of these efforts to create mass-produced, affordable housing prototypes have emerged with shipping containers used as inexpensive "building blocks." The New York-based firm LOT/EK has created several container-based structures including the conceptual Mobile Dwelling Unit (MDU), which is designed to travel with its owner/inhabitant from one long-term destination to another. The transportable live-work space would be able to plug into towers located around the world to obtain power, water, sewage lines, and networking capabilities. Engineer Richard Martin founded Global Peace Containers, a not-for-profit organization that has perfected a system to convert retired containers into housing and community buildings. And Wes Jones and Partners used standard shipping containers as the basic module for their "Technological Cabins" in the High Sierras.

Adam Kalkin's Adriance House (also known as 12 Container House), commissioned as a vacation home, and calls into question "our dependence on historical domestic building conventions and traditions."[27] In addition to shipping containers, it uses scaffolding, concrete, corrugated metal, garage doors, and grating. Despite its industrial appearance, the interior of the 4,000-square-foot house is remarkably sedate. The front and rear elevations are framed by huge two-story curtain wall of glass, which not only invites sunlight but also draws in cooling summer breezes providing more than adequate cross-ventilation. The interior is defined by a huge double-height central open-plan space that forms the main public zone of the house, which includes a living room at one end and a dining area opposite. The living and dining areas are divided by a double staircase which provides access to the bedroom and bathroom cargo modules above. Available at a starting cost of

$250,000 and more, depending on terrain and extras, the 12 Container House is "a home on a grand scale." A smaller five-container version called the Quik Build House can be delivered anywhere in the continental U.S. for $76,000 including shipping (Fig. 5).

The "building block" approach has also been applied to KFN Systems FRED, a modular home-building system that comes in different sizes, square footages, forms, floor plans, and details. FRED is essentially a room that can be electronically expanded with controllable sliding walls.[28] The system uses 5 x 5 meter modules that can be lined up or stacked on top of each other. The types of wall facades are available and the entire system can be adjusted to meet the requirements of the owners. Once the system is delivered to the site, FRED can be fully assembled within two hours. The 5 x 5 meter modules can be lined up or stacked on top of each other. Ten types of wall facades are available and once on-site it can be assembled in two hours.[29]

Fig. 6. Herbert Jacobs House, Middleton, WI, Frank Lloyd Wright, 1944 (left). House_O, Exilhauser Architects (right).

Sustainability has been a driving force in the prefab market for a long time. The "Solar-Hemicycle" houses were a new type of plan-form created by Wright that linked the new development with the original kit Usonians. Its passive design strategies were applied in the second Jacobs House of 1944 using a semi-circular plan with masonry walls and wood (Fig. 6). It was buried in a hillside to take advantage of thermal mass, solar orientations, cooling breezes, and the natural terrain.[30] House_O (Fig. 6) also achieves energy conservation and affordability with a semi-circular shape built into a round prefabricated concrete foundation that Exilhauser Architects call the "Eco Shell." The hollow cement drum, designed for agricultural cesspools, is available in 49-, 57-, and 66-foot widths and the round foundation wall varies in height from 10 to 19 feet depending on the overall house size and number of subterranean levels. The Eco-Shell's concrete walls are sealed with a 5-inch-thick foam thermal insulation layer that, combined with the earth that surrounds its core, offers excellent natural insulation and maintains the interior temperature at a constant 39 degrees F. Prices range according the size of the house. The one-bedroom "Mini" version costs about $96,674 to build, whereas the "Mid 240" at 2,583 square feet costs $225,614.[31]

Conclusion

In a lecture in 1929, Buckminster Fuller was asked whether the mass production of houses would make architects obsolete. He argued that the architect's design expertise would be even more critical with regard to prefabrication due to the social and technical challenges it presents.[32]

Inspired by technological advances and challenged by social and economic realities, architects will continue to push the boundaries of not just prefabricated houses but the idea of housing itself. As this paper has shown, prefabrication combines traditional and industrial materials with contemporary aesthetics to create innovative housing solutions. However, Arieff cautions that if prefabrication clings "to a formula that fails to address the evolving nature of families, the need for energy efficiency and environmental sensitivity, and a more modern vernacular style desired by a new generation of home buyers," it is bound to fail.[33]

Colin Davis insists that vernacular architecture, which is comprised of standard construction details applied to standard building types, can be a model for prefabricated, factory-built architecture. Most houses are standard products adaptable to almost any site and we must be able to distinguish the difference between constructional design and spatial design if we are to truly appreciate building technology. "New technologies designed in isolation on a drawing board are likely to fail," he predicts. "Technologies have to be developed, not designed and you need a factory to develop them in."[34]

Architects such as Frank Lloyd Wright and Walter Gropius, though at opposite ends of the architecture spectrum, believed passionately in the life-enhancing potential of prefabrication as a sustainable housing system.[35] Fortunately, there are today a host of architects and designers who continue to be compelled to explore the possibilities of technologies currently available as well as those yet to be

discovered. The prefabricated houses that they are designing, both in production and conceptually, are helping to alter the prevailing perception of prefab as low quality and poor design.

Endnotes

1. Jill Herbers, *Prefab Modern* (New York: Harper Design, 2004), p. 43.

2. Daniel Willis, "The Work of Architecture in the Age of Efficient Production," *The Emerald City and Other Essays on the Architectural Imagination* (New York: The Princeton Architectural Press, 1999), p. 256.

3. Gilbert Herbert, *The Dream of the Factory-Made House: Walter Gropius and Konrad Wachsmann* (Cambridge, MA: The MIT Press, 1984), p. 18.

4. Colin Davies, *The Prefabricated Home* (London, Reaktion Books, 2005), p. 9.

Although millions of prefabricated houses have been built all over the world, architectural historians have ignored industrialized housing except for a few isolated examples. Thus, the problem of prefabrication has been left to the construction and building industries without much influence or guidance from the architecture profession.

5. "While America continued to experiment with prefabrication, Europe, by contrast, built with it."

[John Burchard, in Albert Farwell Bemis, *The Evolving House V. 3: Rational Design* (Cambridge, MA: Technology Press, 1936), p. 335.]

6. Burnham Kelly, *The Prefabrication of Houses* (Cambridge, MA: Technology Press/Wiley, 1951), pp. 15-16.

7. "If we eliminate from our hearts and minds all dead concepts in regard to the house, and look at the question from a critical and objective point of view, we shall arrive at the 'House-Machine', the mass-production house, healthy (and morally too) and beautiful in the same way that the working tools and instruments which accompany our existence are beautiful."

[Quoted in Allison Arieff and Bryan Burkhart, *Prefab*, (Salt Lake City, Utah: Gibbs Smith, 2002), p. 15.]

8. *Ibid*., pp. 14-15.

Aladdin Houses of Bay City, Michigan was the first company to offer a true kit house with precut numbered pieces. The company sold approximately 65,000 Readi-Cut model homes before going out of business in 1981. Sears, Roebuck & Co. of Chicago sold about 1000,000 mail order kit houses from 1908 to 1940.

9. Arieff and Burkhart, *Prefab*, p. 15.

10. Keck undoubtedly was familiar with Buckminster Fuller's Dymaxion, which had appeared in architectural journals in 1929, and Bauhaus designs, which around this time were receiving widespread attention in Europe. He had purchased an early translation of *Towards a New Architecture* and was obviously influenced by Le Corbusier's concept of the house as a "machine for living." But the inspiration for his particular design can be traced to the Richards House, a three-story octagon constructed in 1853 which was located just a half a mile from his childhood home in Watertown, Wisconsin. It contained a number of features that found their way into the House of Tomorrow: a centralized heating system, a central staircase, and shading devices on the windows to protect against summer heat.

[H. Ward Jandl, *Yesterday's Houses of Tomorrow: Innovative American Homes 1850 to 1950* (Washington, D.C.: The Preservation Press, 1991), p. 130.]

11. Walter Gropius and Martin Wagner, "How to Bring Forth an Ideal Solution to the Defense Housing Problem?" in *U.S., 77 Cong., 1st sess., House Select Committee Investigating National Defense Migration,* 1941, H. Doc. 12, pp. 6949-6956.

12. Herbert, *The Dream of the Factory Made House,* p. 317.

13. Ima Ebong, *Kit Homes Modern* (New York: Collins Design, 2005), p. 25.

14. *Ibid*., p. 29.

15. Of the original eight designers, only Richard Neutra had an international reputation.

[Ethel Buisson and Thomas Billard, *The Presence of the Case Study Houses* (Basel: Birkhauser, 2004), p. 27.]

16. *Ibid*., p. 28.

17. Arieff and Burkhart, *Prefab*, p. 28.

18. Ebong, *Kit Homes Modern*, p. 29.

19. Koenig, who designed Case Study Houses 21 and 22 (the Bailey House and the Stahl House, respectively), regretted that his Case Study Houses were never mass-produced.

[Arieff and Burkhart, *Prefab*, p. 28.]

20. *Ibid*., p. 30.

21. *Ibid*., p. 30.

22. *Ibid*., p. 143.

23. Hebers, *Prefab Modern*, p. 78.

24. Ebong, *Kit Homes Modern,* p. 51.

25. Arieff and Burkhart, *Prefab*, p. 41.

26. *Ibid*., p. 29.

27. Ebong, *Kit Homes Modern,* p. 72.

28. Hebers, *Prefab Modern,* p. 91.

29. Arieff and Burkhart, *Prefab,* p. 97.

30. John Sargeant, *Frank Lloyd Wright's Usonian Houses: The Case for Organic Architecture* (New York: Whitney Library of Design, 1976), pp. 82-83.

31. These costs are based on the conversion rate of the U.S. dollar to the Austrian mark in 2005.

[Ebong, *Kit Homes Modern,* pp. 137-138.]

32. As Fuller pointed out "The architect's efforts today are spent in the gratification of the individual client. His efforts tomorrow, like those of the composer, the designer of fabrics, silver, glass and whatnot may be expanded for the enjoyment of vast numbers of unseen clients. Industrial production of housing, as contrasted with the present industrial production of raw materials and miscellaneous accessories, calls for more skill and a higher development of the design element, not its cessation."

[Quoted in Arieff and Burkhart, *Prefab*, p. 36.]

33. *Ibid*., p. 36.

34. Davies, *The Prefabricated Home*, p. 203.

35. Ebong, *Kit Homes Modern,* p. 34.