Postwar Living Systems

Architectural Modularity and Prefabrication in Early to Mid-Century America

A great new epoch has begun…
We must create the mass production spirit.
The spirit of living in mass-construction houses.
The spirit of conceiving mass-production houses.

-Le Corbusier[1]

• • •

Allan Berry

University of Illinois at Chicago
Department of Art History

The second of two papers to fulfill a thesis equivalent toward a Master of Arts

Reader #1: Professor Robin Schuldenfrei
Reader #2: Professor Esra Akcan

Wednesday, April 27, 2011

Introduction

Since the advent of the industrial revolution, periods of preoccupation with prefabricated architecture have occurred, generally timed to periods of cultural change, social instability and uncertainty in the housing market; such periods tend to eventually evaporate when interest wanes and more traditional techniques and ideas reassert themselves. During the period surrounding the two World Wars, however, a systematic reevaluation of architecture took place, when many of the principle theories and methods of modular architecture were expanded and codified, taking firm root in architectural practice and theory. Modular architectural techniques allowed prefabrication to establish itself as the dominant means of building, and has remained so since.

There is no shortage of examples of prefabricated or modular construction from the period: the topic is pervasive in contemporary academic, technical and popular literature. Industry publications about prefabricated architecture are particularly common, picking up noticeably after American troops returned from overseas in the mid-1940s.[2] With this in mind, I do not intend to conduct a survey of all modular methodologies, or to provide a systematic classification of prefabricated architecture. An established theoretical literature exists, in particular the works of Albert Bemis[3] and Konrad Wachsmann,[4] two figures of the period who laid down a systematic methodology of modular construction (and to whom the literature often refers). Other, more modern writers, in particular Herbert Gilbert,[5] have further expanded the literature.

Despite this penetrating scholarship, most incisive examination of modularity and prefabrication exists instead in the technical press: not usually considered on their own, modularity and prefabrication are usually instead considered as tools for the architect or engineer. In the technical literature they have been relegated to usefulness; with some exceptions, aesthetic or social qualities of the module are generally disregarded as accidental byproducts. This is not to deny the eminent usefulness of the module, or the prefabrication which accompanies it. Modular

and prefabricated architecture provide industry with economies of production hitherto unknown, and consumers with more choice and supply than otherwise would be possible. But this is only half of the story, as the module itself is not aesthetically inert: it fundamentally effected architectural form, and left a distinct stamp upon the broader landscape.

This may indicate a broader shift in during the Modern era, an apparent split between high and low in the mode of Clement Greenberg. The technical press, aimed squarely at the working housing designer in the broadening suburban landscape, tended to give short shrift to form, ignoring it whether it followed function or not. However, on closer inspection, the split seems an illusion. Architects both plebeian and elite paid attention both to function and form, albeit with varying emphasis. Sometimes the question became moot, as the form of the module carries an inherent aesthetic whether acknowledged or otherwise. By and large, preeminent architects of the day recognized that the module, and the increased prefabrication it offered, was a seminal development; while noting that its form should not be taken for granted, they were often complacent in providing the module with the same formal attention of previous generations. If any disregard of form was widespread during the period, elite architects may be as much to blame as the technical press or the working architect. Regardless, such disregard may have contributed to resistance of the new architecture in some quarters, especially regarding domestic architecture destined for mass consumption, for an audience and industry not immediately inclined to abandon established aesthetic norms; in retrospect, a greater pragmatic emphasis on appearance might have eased the introduction of new techniques.

The Basics of Modularity and Prefabrication

Modularity is not a twentieth-century phenomenon, of course; it can be traced back at least to fifteenth-century Japan, in which noble dwellings were designed around the standard size of the tatami mat. Even Greek temples follow somewhat modular systems: “the Parthenon is the

product of selection applied to a standard," stated Le Corbusier.[6] The nineteenth-century Crystal Palace of Joseph Paxton was designed along a modular framework, with parts fabricated in a remote facility, merely assembled on site, modular enough that it could be dismantled and moved. In light of this, the great advancement of the twentieth-century was the widespread adoption of concerted modularity and prefabrication for use in standard, everyday building projects, for common housing no less than marquee commissions or skyscrapers.

Prefabricated architecture, of which modular architecture might be considered a subset, itself contains general intrinsic appeal for architects and their clients. Since most construction is not conducted on site but instead within factory walls, far less waste material is produced, and less time is necessary for construction. Thus, when adopted on a wide scale, prefabrication can cost significantly less per housing unit, and make more effective use of available labor. Greater precision is possible in the factory than in the field, enabling a consistently high level of quality relative to traditional construction methods.

On a societal level, prefabricated housing makes perfect sense, especially (as in Europe) when the basic underwriter of housing is the government itself. In the United States, I will demonstrate below that opponents of government intervention in private industry can rally around prefabricated housing, for such construction presumably requires less government direction than traditional, and more expensive, building methods. Socially conscious investors can support the concept of widespread prefabricated housing while simultaneously exhibiting the potential for personal profit. Indeed, early twentieth-century entrepreneurs and inventors could hardly fail to perceive the glamor Henry Ford achieved via industrial production: the potential existed both for changing the world and becoming wealthy in the process.

Classifying the Module

What is modular architecture? On its most basic level, a module is a standard measurement. The Oxford English Dictionary describes this as "a length chosen as the basis for the dimensions of the parts of a building, esp. one to be constructed from prefabricated components, all the dimensions being integral multiples of it."[7] But a module is also an object; in architecture, a module is both the dimensions of a building part, as well as the building part itself adhering to such dimensions. It is a component of a system.

Modular architecture thus implies a systematic design composed of separate, standard components, which can be connected together with standard interfaces *(fig. 1)*. In modular architecture theoretically any component could be replaced or added without affecting the entire system, because the rest of the system would not require redesign to effect the change. Such design carries obvious benefits both during the phases of construction and maintenance, when a missing or broken piece might be ordered from a factory with little extra planning or consideration, and when implemented, would work exactly as expected. In a sense, the module is a cog in Corbusier's machine for living.

For the sake of classification, I will suggest to break modular domestic architecture into three broad categories:

micro-modular tier

The first level, which we might call *micro-modular*, indicates limited systems where modules are used for internal components or details, like the Red-Blue chair of Rietveld. On this scale, a kitchen drawer is a modular part of a kitchen system, interchangeable with other drawers, and of standard size to other kitchen components, e.g. appliances. The various parts, or features of a house, can be replaced or upgraded as needed.

mid-modular tier

On the second level, which we might call *mid-modular*, modules define the house structure itself. This is the layer with which Corbusier is chiefly concerned, wherein a house is defined by its system of modules. In the most thorough examples of mid-modular construction, such a system can extend both into the micro-level and the larger macrocosm, integrating both the internals of the house and the house into the larger systems of which it is a part.

macro-modular tier

At the top level, which I will term the *macro-modular*, a whole house fits into a unilaterally designed structure, that is, an urban plan. If the goal of an urban plan were to implement the most efficient and cost-effective system for housing the greatest number of people, then it would make sense to solve the problem of housing a family once, and repeat the solution ad infinitum instead of reinventing each component anew. In this scenario, the house becomes a component in a broader system, a module itself, possessing an interface and functions all its own, while not necessarily exhibiting modular features on any lower level. Each house shares the same physical layout, including attachments for electricity, plumbing, and a driveway for a standard-sized car; that is, the house possesses standard interfaces both for its inhabitants and the broader system of which the house is but a component. In the United States this domestic systems approach took the form of suburban sprawl, and Levittown may qualify as a macro-modular settlement, although without complete application of contemporary modular principles *(fig. 2)*. In other words, suburbia resulted from the need not just to house returning veterans, but to do so in as efficient a manner as possible: a domain perfectly suited to the module. However, such projects were tempered by an industry resistant to the potential of thorough application of the module, so their success is, at best, limited.

Each of these levels is modular in its own right, and none are mutually exclusive: a house can be micro-modular and macro-modular without being mid-modular, or mid-modular and micro-modular without being macro-modular.

Corbusier: Legitimacy for Prefabrication

Much of the credit for theoretically legitimizing modular construction can be attributed to the architect Le Corbusier. His Dom-ino house of 1914 might be considered the first such structure to gain widespread attention, containing the major elements of modular, prefabricated construction: reinforced concrete poured on site, with a superstructure of standard-sized, repeatable elements *(fig. 3)*. Indeed, in his 1931 treatise *Towards a New Architecture*,[8] Corbusier expounds his predilection toward prefabrication:

> We must create the mass-production spirit.
> The spirit of constructing mass-production houses.
> The spirit of conceiving mass-production houses.[9]

A decade after World War II, Corbusier finally delineated an accompanying theory of modularity, in his 1954 book *Le Modulor*.[10] From his perspective, the use of the module was elemental to any new architecture. Based as it was upon the human form, the module was a perfect, practical tool for constructing human dwellings, and central to any architecture trying to establish a new, elemental, abstract language. To Corbusier, the use of standardized measurement was a choice independent of visual aesthetics: a scale analogous to that in music, an organizing principle for an art form, separate from any notions of quality *(fig. 4)*.[11] Thus, beauty is independent of measurement, standards do not preclude beauty, and if we would have mass-produced architecture, we may as well adopt a standard structure. As Lawrence Anderson explains,

> Architects' enthusiasm for the module shows a hunger for discipline… the module can give unity to buildings, but it also can be used as a crutch, an invitation to impose a pattern of rectangles (or hexagons) without an awareness of the problems of scale and of the need for beginnings and endings. Le Corbusier has shown in his Modulor how geometrical unity can be based on subtler dimensional relationships. To put hundreds or thousands of identical cells together in one visually satisfying structure requires strong principles of organization.[12]

On the other hand, for Le Corbusier such observations were perhaps beside the point, as systems had become "esoterical, shrouded in mysticism,"[13] requiring the efforts of the architect toward their liberation. To Corbusier, standards do not arrive by accident, but are rather painstaking results of logic, analysis and study, evolving from the requirements of a clear problem.[14]

During Corbusier's lifetime, the module evinced a paradigm shift for architecture; in addition to "space," architects increasingly concern themselves primarily with "the object." When positive mass is considered paramount instead of negative space, primary attention must be paid to the ways objects physically interact. Interaction is their interface, their function. This falls in line with the consumerist tendencies of the age; although the ubiquitous International Style architecture of the period does consider space as paramount, architecture of the postwar period in America, at least, inexorably becomes the sum of its *features*: positive elements, with space taken for granted or mentioned as an afterthought. Mass-market houses were noted less for any amorphous notion of space than for concrete buzzwords, with those features able to be listed on a broadsheet advertisement paramount. Therefore, Corbusier's preoccupation with the module itself was at least contemporary for his time, even perhaps anticipatory. His oft-quoted maxim, that the home was a *machine à habiter*, exemplifies this: although the machine provides room in which to live, a machine is nevertheless the sum of positive parts, not of negative vacuums.

Rietveld

The module is not, however, entirely a functionalist tool, but fits tightly into aesthetic systems as well. As Johnson and Hitchcock state in *The International Style*, "good modern architecture expresses... an aesthetic ordering which emphasizes the underlying regularity;"[15] we see the module at least can aspire to an aesthetic justification.

Although he was not an American, when considering modular development during the twentieth-century, it makes sense to consider Gerrit Rietveld, in order to demonstrate at the outset an alternative to simple functionalism. Rietveld was, perhaps, a holdover from a previous generation, dressed in modernist trappings. Not an industrialist by any means, Rietveld was at least as directed by the aesthetic qualities of the module as with any functional aspects. He noticed that the size of a modular unit has direct consequences on an overall visual structure, as small units are difficult to discern in the gestalt. "Although small units are technically valuable, only large units are optically effective, since small dimensions are swallowed up by the space."[16]

For example, in Rietveld's Red and Blue Chair of 1917, a modular system is explicitly employed primarily for visual effect, perhaps at the direct expense of comfort *(fig. 5)*.[17] The module is of primarily aesthetic concern: practical uses are of decidedly secondary importance, and mass-production is hardly considered. This seems distant from the Sullivan doctrine of form following function, and rather closer to the prevailing *fin-de-siècle* notions of the previous generation, that decoration and appearance were ends in themselves. Rietveld treated the module like a decorative element: ineffective in isolation, serving to define a space only via its multiplication. For Rietveld, modules were not mystical or practical elements like for Corbusier, but just like any other tools in his toolbox, to be used or ignored at will.[18]

Thus, when Rietveld considers modular units, he values them on grounds of size and appearance rather than any humanistic or procedural qualities: "although small units are technically valuable, only large units are optically effective."[19] This attention to aestheticism may have been essential for acceptance, as aesthetic resistance by the populace may have been the first hurdle to overcome as modular theory became widespread. As the module is employed only on the micro-modular scale, without any need to integrate with broader context, Rietveld enjoyed some of the independence of the painter; the Red and Blue Chair need only fit into an oeuvre, not a system. Thus, the potential of the module is elementary and limited, whether for aesthetic or functional purposes, and therefore does not live up to its potential.

It seems unsurprising therefore that Rietveld found the module ultimately unfulfilling. He left modules out of his 1924 Schröder House entirely, and employed them only sparingly in his later work.[20] Despite Rietveld's ambivalent treatment of the module, he elucidates that objects have appearance by nature, for better or worse, and even if a module's form is ignored, it still exists and influences surrounding forms. Regardless of functionalist notions, or whether the module is conceived as formalist exercise or as utilitarian means, it must dwell in both arenas. Any theoretical split is artificial.

Wright

In a long-distance affinity with Rietveld, Frank Lloyd Wright, the preeminent architect of his generation in the United States, took modularity several steps further, while retaining an essentially aesthetic bent. Wright saw fit to use modular systems extensively in his late work; two prominent examples are his Hanna House of 1936 and the Kinney House of 1951. His use of modular forms eventually became a system of forms: all primary angles in this system were 60 or 120 degrees, designed within a network of repeating units, which allowed an extraordinary amount of variation within concrete limitations, while maintaining a gestalt consistency.[21]

In his Hanna House, Wright began to implement non-rectangular geometry, which accompanied the need to use a hexagonal module for spatial organization *(fig. 6)*. Other houses of the period which exhibited non-rectilinear modularity were the Patrick Kinney House of 1951, the Richard Smith House of 1952, and the Ralph Tyer House of 1952, all of which use the same basic hexagonal module scheme.[22] Wright believed that such a system was an example of his notion of "reflex," that is, that form can directly influence human behavior.[23] Of primary importance in this work is the sociological function of the house: the diamond/hexagonal module was not primarily chosen for its formal characteristics, but rather for adherence to sociological precepts concerning education and the family.[24] Joncas explains that "the implication behind the notion... was that the hexagonal form, as well as its pattern of diagonality created by the obtuse angle, can influence human behavior by determining its rhythm."[25] According to Wright, it is "a pattern more natural to human movement is the result. Interiors have more reflex. Therefore more repose *[sic]*."[26]

For Wright, the system of horizontals, hexagons and circles formed a basis toward imposing unity on manifold parts, from both an aesthetic and sociological point of view. With abstractions derived from his clients' needs, Wright's process was to reduce complexity down to a simple formal conception, and then to repeat and magnify this conception back to complexity. As Bernard Pyron explains, Wright considered the hexagonal module as "organic," a term "highly suggestive of forms in nature… for Wright, 'organic' meant growth from a central idea, meaning that a particular idea or motive permeates the whole structure of a house. For example, in the houses that are based on a triangular-hexagonal idea, all areas are variations of the triangle or hexagon."[27] With enough repetition and variation of modular components, his module eventually became something like ornament.[28]

Indeed, modularity and ornament are closely intertwined throughout Wright's career. Three distinct periods emerge in his work: an early period where modules were somewhat subservient to ornament, a middle period where ornament was subservient to modules, and a later period wherein he reached some sort of synthesis, using modules as ornament and vice-versa.[29]

In his 1946 autobiography, Wright stated his position on modularity as clearly as possible, oddly echoing Corbusier in the process:

> ...music and architecture blossom on the same stem: sublimated mathematics. Mathematics as presented by geometry. Instead of the musician's systematic staff and intervals, the architect has a modular system as the framework of design.[30]

Development of Prefabrication and Modular Application

The aesthetic sensibilities of Rietveld and Wright were not, however, necessarily the norm. During the years before the Second World War in the United States, consumer domestic design began to absorb advancements previously relegated to industrial products. The module and prefabrication increasingly were valued not for their aesthetic sensibility, but for their accord with industrial manufacture. While the formalist/functionalist debate would never entirely vanish, architectural fashion leaned more and more toward the aesthetic of the machine.

The late 1920s and the early 1930s brought the "streamline" aesthetic into the public consciousness. The creations of Norman Bel Geddes became part of the nation's cultural currency, and during the 1930s, the nation was exposed to ubiquitous streamlined designs pervading everything from automobiles and airplanes to teapots and radios. Such "aerodynamic" forms were drawn from contemporary advancements in transportation, and conveyed a feel of dynamic functionalism, in contrast with the more geometric Art Deco styles of the 1920s which conveyed a more static, stable feel. Streamlining conveyed notions of speed, of saving time and energy, imbued with notions of progress: during the Great Depression, streamlining encouraged notions

of hope to Americans struggling with economic depression.[31] Architecture more and more drew inspiration from the machine, and from transportation more generally: the domain of mass-production and the module.

While such designs may have been primarily superficial, a mere veneer of progress, they fundamentally familiarized the American public with the inherent aspect of the machine. Such streamlined forms paved the way for American consumers to accept less traditional designs into their living spaces. Where before a consumer might only consider a traditional Cape Cod or Colonial when purchasing a new house, now they would not, at least, be immediately repelled by a mechanical appearance. This may paradoxically have provided architects and engineers with the breathing room to explore nontraditional, industrial building practices, including broad adoption of modular construction. As Rietveld promoted a handcrafted, thoughtful, aesthetic experience, other practitioners of the period diligently explored the module's technical potential, often ignoring aesthetics as thoroughly as Rietveld ignored industrial application.

Fuller

One of these enterprising new designers was R. Buckminster Fuller. Not primarily an architect by training, Fuller was instead a multi-faceted thinker, having contributed to fields as diverse as automobile engineering, social engineering, chemistry and geography. Although an eminent functionalist, his designs paradoxically influenced the look of the 1920s, and helped to define the streamline aesthetic.

Throughout the 1920s, Fuller had been experimenting with building design using industrial, modular components. For example, a company he incorporated with his father-in-law, Stockade Building Systems, produced structures with a modular brick design, in which fibrous bricks of wood shavings were stacked and filled with concrete for reinforcement. This company grew to possess five factories, and produced over two hundred homes.[32] When this enterprise eventually

folded, Fuller began to clear the cobwebs of domestic design with his Dymaxion creations, designs "for a new way of domestic living, suggesting the mobility and speed of modern life, its temporary nature and expandability."[33] Fuller applied his Dymaxion theory (a combination of the words "dynamic" and "maximum") to dwellings, theorizing ing stark utilitarian language. The concept called for tackling problems with utmost rationality, with little attention paid to tradition or accepted norms, instead a striving for the most efficient overall performance for every social and industrial use.[34] Industrial output, whether regarding airplanes or homes, must provide the greatest net performance output proportional to the amount of energy used.[35] In this sense, form was not relevant, as long as the required function of a structure was well served. To Fuller, perhaps even more than for Corbusier, dwellings were "environment-controlled machines,"[36] more literally *machines-a-habiter* than the more lyrical creations of his European contemporaries.[37]

Fuller was impressed with the capabilities of vehicles, both in the means of their production, as well as their inherent characteristics: their mobility, the lightness of their parts, and the flexibility of their configuration.[38] In 1927, Fuller created his Dymaxion House: a hexagonal, self-contained living module *(fig. 7)*. The house could be manufactured in a central location like an airplane (and with similar techniques); it was suspended above the ground via a central mast, and accommodated all of the main needs of a small family.[39] The building could be extended and its facades reconfigured. The Dymaxion house could therefore be considered a mid-modular system; in addition, because of Fuller's overarching ambitions toward mass-replication, it may also be considered macro-modular. Fuller even considered the micro-modular, in that building services could be "plugged in" and swapped with more modern technologies as they arrived on the market.[40] The Dymaxion house thus was designed from the ground up as a modular, prefabricated system, and was correspondingly flexible and efficient.

Fuller tirelessly promoted new technological solutions to housing problems, in particular his invention the Geodesic Dome. Attempting to replicate the inherent structural properties found in the atom and its nucleus (a novel source of inspiration in housing design), he found that a dome made of triangular chords possessed unparalleled advantages in light of traditional construction methods. Fuller considered the dome as the most efficient form for shelter: "there is a special advantage of the hemisphere over other geometrical forms… the upper or enclosing surface of a hemisphere is always twice the area of its base. The upper surface of a cube is always five times its base. The above ratios indicate clearly the initial advantages of curved enclosure over rectilinear."[41] Domes can easily shed water and snow, can be made from fewer and lighter materials, have better potential for air circulation, and can be made of standard components. They can withstand extreme forces, whether earthquake, hurricane, arctic cold, or tropical heat, forces with which existing buildings at the time could hardly be expected to cope.[42]

Fuller envisioned these Geodesic structures as all-purpose dwelling encasements, useful for everything from quickly-erectable camping tents, military Quonset hut replacements, single-family housing, and even perhaps for the enclosure of entire communities *(fig. 8)*. In any case, the module is everywhere, both in the dome itself, as well as in any structures underneath. In the dome, icosahedrons are formed from a limited number of precision pre-constructed spars, factory produced in advance, and merely assembled on site. The dome is nothing *but* an assemblage of modules.

Articles in the industry press during the 1930s took it for granted that modular housing was just around the corner, and, at least in the press, fewer demerits were attached to novel aesthetic forms. The industry as a whole was taking stock of the new developments, and saw in prefabrication the potential for new markets. An *Architectural Forum* article of 1935 makes this clear: “It is self-evident that as soon as a house better than the conventional one of the same price,

less troublesome to run, more comfortable to live in and more economical to operate and maintain is produced and put on the market, the public will buy it regardless of whether it is modern in style, has new finish materials inside or outside, has a flat roof or has no cellar or attic."[43]

Yet, apparently Americans regarded such experiments as alien, not yet ascertaining their potential practical outlet. Although public interest was intense, and despite the production of some Dymaxion house prototypes in 1946 by Beech Aircraft of Wichita, the costs required for tooling and full-scale manufacturing could not be achieved.[44] As Gilbert Herbert somewhat mournfully observes, "the Dymaxion house remained no more than a tantalizing promise, a highly innovative prototype."[45] Fuller faced similar hurdles with the production of his 1933 Dymaxion automobile and his prefabricated bathroom (stamped from a single piece of steel), which were exhibited in 1937.[46]

This seems to be an emblem of the era: although the ideas, plans, enthusiasm and, possibly, the demand existed, the inherent risk involved for such novel solutions nevertheless struggled to pass muster with industry. Architecture may have been the last industry not yet exploited by mass-production in the United States; other major industries, whether automobiles, appliances or agriculture had long since felt the direct influence of the machine. From Fuller's perspective, architecture was simply having trouble gaining the same sophistication as other industries. It was stalled in development. Somewhat defensively, in retrospect, he framed the challenge thus:

> The design concept does not include such criteria as public acceptance or profit but rather we have tried to carry on a scientific prototyping activity to show how the house product can be designed for performance. We are interested in making a better house rather than realizing an immediate profit. This might be compared to the airplane - a considerable period elapsed before the airplane became a sound financial proposition.[47]

Some of the social inertia may have been aesthetic, or at least concurrent with an industry perception that the public was unprepared to accept homes mimicking machines. Regardless of the accuracy of these perceptions, because of their mechanical origins, modules tended to carry an impersonal, inhuman stigma. For all of the novelty of the Geodesic structures, for example, Fuller applied the same basic design to many divergent problems, with little variation allowed for inhabitants or locales. Modular application can be cold or monotonous: in buildings in which people live and work, those people must inevitably cope with a certain amount of monotony in regular, repeated, unadorned forms.

Nevertheless, when society is in need of housing, and traditional forms are insufficient to meet the demand, new forms will inevitably fill the vacuum. As all houses perform the same basic functions, there are more reasons for houses to be alike than to be different.[48] J. Andre Fouilhoux wrote, in 1935: "The idea has been drummed into us that nothing is worse than repetition. And the barracks called dwellings in industrial towns have been held up as proof... standardization has become an academic question; machine techniques and economic pressure have made it a fact."[49] Fouilhoux was hardly alone in proclaiming the economic realities of mass-production, that it must eventually trump reactive hesitation: if modern, modular housing has the potential to solve problems in the world, it is only a matter of time before the world must simply adopt and learn to adapt. This does not mean that aesthetics are unimportant, but rather that any public aesthetic, whether real or imagined, must evolve along with technology, and work to shape it to be more human.

Prefabrication in Production

Prefabrication finally penetrated the American consciousness during the 1933 Century of Progress exhibit in Chicago, where George Fred Keck's House of Tomorrow was exhibited; the wonderment caused by this futurist exhibition did much to interest the general public and allay

many remaining public fears of modernism. By 1936, when Albert Farwell Bemis published the three volumes of his seminal work *The Evolving House*, mass-produced housing was increasingly seen as an inevitable development *(fig. 9)*. Micro-modular construction was mainstream by 1938: "utilitarian devices, such as heating equipment, kitchen cabinets and plumbing fixtures, to mention only a few, have already been carefully standardized with attendant advantage to all concerned."[50] Bemis predicated the first instance of a thorough application of functionalist theory to structural method:

> Mr. Bemis recognized that if agreement could be reached among all concerned, on the same set of standard dimensions, so that brick, wherever manufactured, would lay up to standard window openings into which standard windows could be set and so on through the structure, then building efficiency could be improved and substantial savings could be made. He conceived a standard four-inch "module," or measure, as the basis for this "dimensional coordinator."[51]

During this period, European techniques and ideas had great impact on American modular prefabrication, simply because the Europeans were more advanced, perhaps as much as 20 years ahead of America in concept and practice. According to Herbert, "while America continued to experiment with prefabrication [in the interwar years], Europe, by contrast, built with it."[52] The Europeans were simply doing more with prefabrication during the interwar period, essentially importing it into the United States before the war and assisting with its implementation afterward.

Postwar Prosperity and the Housing Boom

After victory in war due in no small part to widespread mass-produced goods, industrialists in the United States of the late 1940s and early 1950s naturally thought to apply such effective techniques to other realms and issues. Encouraged by government programs like the Federal Housing Authority, droves of veterans returning home from overseas demanded single-family

homes, creating a demand which quickly outpaced supply. The Federal Housing Authority granted loans via the GI Bill, and involved itself directly in encouraging the housing industry to increase supply, via financial incentives and expertise. The predictions of Fouilhoux came to pass: existing paradigms of custom construction could hardly keep up. Despite some unease with the Federal Government's policy of encouraging and underwriting housing, considered by some as "potential competition and further evidence of the 'creeping socialism' of the New Deal,"[53] industry finally seemed willing to accept the challenge.[54]

Of course, making mass-produced housing was not as simple as making radios or even automobiles: in real estate, of course, location is everything, and a house produced for one location might not have the same value in another. Such a complex commodity required substantial industrial plant and significant capital outlay both for development and delivery.[55] However, the ingenuity of equipping an army with novel industrial equipment, and the prestige of being successful in the endeavor, provided builders and investors with the confidence to shake off inherited norms. The war invigorated American industry, which had been half unemployed since the beginning of the depression. War forced massive acceleration in productivity, while laying the basis for broad, qualitative change in American technology.[56]

As Gilbert Herbert writes, "more often than not, prefabrication has flourished in emergency situations: a new colonial settlement, a military outpost, a mining town, a tornado, a war."[57] Times were ripe for industrialized architecture of all sorts. By the 1940s, building materials were, by and large, mass-produced. Large building projects were being directed in central locations, according to efficient routing procedures and according to economies of scale, even though final construction was being performed in the field.[58]

Material producers, liberated from wartime restrictions, found themselves with sudden access to materials, manpower, energy and ideas previously locked up in wartime production. Entrepreneurs were quick to see the possibility of tackling the housing problem with the same tools which had won the war, especially the previously overlooked techniques of mass-production. Houses and buildings increasingly were at least partly built offsite and merely assembled. Some homes were built entirely off-site, simply moved to their location upon completion.

By and large, architects were ready for the prefabricated transition, their drafting tables overflowing with new ideas for architecture. This was a period of rapid change in architectural thought spurred by strong demand in the housing sector. Not only were previous conceptions and construction methods increasingly inadequate to deal with severe national housing shortages but, after the chaos of war, architects were interested in finding something more relevant to their time and situation. It was generally acknowledged that American architecture could not simply repeat modes well worn before the war, although the insecurity in the situation was palpable. According to Herbert, "[Many architects] were uneasily seeking a new discipline in a world when time-honored architectural standards had been abandoned and, with them, that sense of design security that comes from working within an established canonical framework."[59] It was time for a new canon to be established.

Modules in the Mainstream

In a symposium in 1948, attended by such luminaries as Henry-Russell Hitchcock, Alfred H. Barr Jr., Eero Saarinen, Walter Gropius and Marcel Breuer, a divide in approach seemed palpable: although much of the same visual elements were used by architects across the board, some stressed the style of the elements in an historical context, while others primarily concerned themselves with problems of need and production.[60] Hitchcock, for example, was concerned with

problems of form: he spoke of "monumentality" and "expression" while many of the Europeans, including Gropius, downplayed formalism in favor of social awareness and the individual. Perhaps this split indicates how different continents suffered during the war; America, flush with cash and valor, lacked nothing but validation for power, while a spent Europe wallowed in material shortage, international distrust and gloom.

The Packaged House

Walter Gropius, who left Nazi-controlled Germany in the mid-1930s and settled in the United States, went out of his way to embrace local values. Instead of applying European predilections for high-density housing (as was popular then in many European countries), Gropius made it a point to use high-density techniques to deal with low-density problems, making his ideas in some ways more American than the American avant-garde often more preoccupied with socialist European mass-housing.

By the time of his emigration, Gropius already had extensive experience with modularity. Even before the First World War, Gropius had intimate knowledge of industrial residential architecture, in particular workers' housing, gathered under the guidance of Peter Behrens at AEG.[61] During his years at the Bauhaus in the 1920s, Gropius dictated that "the Home and its furnishings are mass consumer goods, and their design is more a matter of reason than a matter of passion... the creation of standard types for all practical commodities of everyday use is a social necessity."[62] In particular, according to Herbert, Gropius felt that industrialized housing must be "designed for maximum utility, standardization, and interchangeability of the parts and maximum variability of the whole, the house as a final product. This industrialized building system moreover is not an end in itself, but an integrated part of a larger whole, one level in a hierarchical environmental-social economic system."[63] This "interchangeability" and "variability" meant that, in his eyes, modular construction superseded any superficial repetition. Modular

construction carried the potential of endless customization, as modules (once fabricated) can be put together quickly in any form, and reconfigured afterwards. If such construction did not have an acceptable form at its inception, its very impermanence allowed the flexibility to update its form, if necessary, after the fact.

In this way, Gropius and Fuller shared much of the same utilitarian vision, despite their varied backgrounds and approaches. I don't intend to imply that either had no notion of style or aesthetic concern; flat roofs and white façades, for example, are not simply results of pure function. Nevertheless, at least Gropius was not alone, among the panel, in championing function over form. This was not a universal perspective. Much preoccupation with style (for its own sake) still percolated among the intellectual class in the United States. For example, George Nelson asked for a shift toward expanding design-awareness, away from styles and "isms" into new realms of technology and excitement.[64] Architecture in the postwar period was hardly monolithic.

During the postwar period, the form/function split was hardly limited to eminent architects, as even popular magazines displayed it in sharp relief. While providing many options for the would-be homebuyer, two overlapping predilections emerged: on one hand, would-be buyers of modernism were interested in the aesthetics of production, that is, repetitive modular forms, centralized mechanical services, and other visual byproducts of prefabrication. On the other hand, buyers were attracted to the use-value of the new structures: the flexibility, open-storage and layout options, panoramic views afforded by expanses of glass, and the simpler maintenance they afforded.[65] At least regarding domestic interiors, traditional layouts were, by and large, avoided in favor of the new modern look, whether for its own sake or not.

Home buyers were less enthusiastic about embracing modernism for a home's exterior. Although many publications and magazines advertised prefabricated offerings with tag-lines

thinly paraphrased from Corbusier's "machine for living" epithet, the look of these homes required a more traditional aspect to reach market.[66]

A friend, compatriot and sometime colleague of Gropius, Konrad Wachsmann, joined him in Massachusetts in 1941, after Gropius arranged Wachsmann's release from a French prisoner of war camp. For Wachsmann, modular prefabrication was an established reality. He wrote that "a house designed by an architect was but a house, whereas a system of prefabrication could generate thousands of potential dwellings."[67] Wachsmann and Gropius proceeded to design and implement an elaborate blueprint for modular house prefabrication and distribution. Wachsmann had actually already conceived much of the design while still in Europe, and leapt into the project with gusto, spending countless hours refining and perfecting the plans, while Gropius contributed the extensive experience he had gathered via similar projects in Germany. According to Herbert, "Wachsmann was the essential innovator of detail. Gropius... provided the theoretical framework"[68] of the project. After a year of work, Wachsmann moved to New York, almost penniless but full of fire, with a sheaf of patents in his (and Gropius') name, and started the General Panel Corporation with the express desire to manufacture modular housing on a grand scale.

The Packaged House, as Wachsmann's creation was called, was a complete system for building houses with as little work done on site as possible *(fig. 10)*. This system could be described as an open-ended, nonstandard framework, intended instead to provide a great variety of design options which could not be predetermined.[69] It was extremely flexible, allowing any number of possible options, with extreme speed of erection: an individual-family-sized house could be erected and taken down in a single day.[70] The system was equally useful for building a small two-bedroom dwelling, a military Quonset hut of any length, or a two-story office building. Houses could be flat-packed, and in a disassembled state could be transported like any other

manufactured good. Essentially, the Packaged House was not a house at all, but instead was meta-architecture: a system for building houses. Where an automobile factory would build one car at a time, the Packaged House factory would produce a steady stream of components. That is, it was the goal of Wachsmann and Gropius to produce panels and fasteners which would then be bought in quantity to make houses. The system thus consisted of a very few components, which could be used in unlimited configuration.

By 1942, wartime temporary housing was in full demand, and Wachsmann fully expected to take the industry by storm. Military orders for paneled Quonset huts were ideal for the project, and the postwar housing crisis promised renewed demand for at least a few years afterwards. However, by 1950, the entire enterprise had collapsed "with a whimper:" while the factory and product line did reach operational status, only around 200 functioning houses were built.[71] In addition to the apparent systemic inertia which confronted Buckminster Fuller in earlier decades, the principle obstacle to Wachsmann and Gropius seems to have been that the sheer scale of the project was underestimated from the outset; it was simply too much for a single company acting alone with a proprietary modular system. Perhaps standards cannot be imposed *a priori*, instead requiring industry consensus. At any rate, the Packaged House exists today mainly on paper, an idea ahead of its time.

Case Study Houses

Other major architects of the day experimented with modularity and prefabrication. Indeed, leafing through architectural journals of the postwar period, the words "prefabrication" and "module" reliably percolate the prose: they were buzzwords for their time. The prewar fascination with these concepts had caught on among the architectural press, at least; industry was listening, and the population was, despite some reticence, interested in the new developments.

Immediately following the war in 1945, *Art and Architecture* magazine sponsored the first of their Case Study houses: showcases of the latest avant-garde ideas and methods in architecture, with the expressed intent to encourage efficient, novel architectural ideas to satiate the postwar housing shortage. This program eventually gave great exposure to many of the major architects of the day, including Richard Neutra, Raphael Soriano, Craig Ellwood, Pierre Koenig, Charles and Ray Eames, and Eero Saarinen. Many of these creations contained modular elements, and dealt with them in terms both of aesthetics and utility.

The July 1950 Case Study House #9, designed by Charles Eames and Eero Saarinen, perhaps most vividly integrates the module in its inception *(fig. 11)*. By this time, Saarinen had had long exposure with both modules and prefabrication. In 1942, for the United States Gypsum Company, Saarinen had designed a "demountable space" modular building closely related to Buckminster Fuller's 1927 Dymaxion House design, consisting of a central mast and tensile skin.[72] This design could be extended, façades could be reconfigured, and various services were plug-and-play, the very essence of modular utilitarianism. Various combinations were possible, which could be configured by the needs of circumstance.

Eames' and Saarinen's Case Study House displayed this sensibility as well, in extremely refined form. In his proposal, he called for a variety of preassembled components, which could be combined in arbitrary fashion, around an essentially preassembled core: there was no pretense of extensive, in-the-field handwork, but rather the house was assembled of prefabricated parts: a mid-modular system. It used a standard module, was of steel-and-glass construction, and had a flat roof.[73]

The Case Study Houses, in particular the Eames and Saarinen design, paved the way for public acceptance of modern, postwar architecture, and perhaps helped to popularize modular prefabrication, including any inherent aesthetics. According to the original project

announcement in the January 1945 issue of *Arts and Architecture*, they were intended to be repeatable, practical solutions for housing:

> For average prospective house owners the choice between the hysterics who hope to solve housing problems by magic alone and those who attempt to ride into the future piggy back on the status quo, the situation is confusing and discouraging… we hope it will be understood and accepted as a sincere attempt not merely to preview, but to assist in giving some direction to the creative thinking on housing being done by good architects and good manufacturers whose joint objective is good housing.[74]

Of particular note in this passage, is that builders and contractors are not referred to as such, but instead as *manufacturers*. Apparently, the industrial role of contractors was already taken for granted. Also of note is an explicit distancing of the magazine and the Case Study Houses from "miracle" designs or pure traditionalism, instead aiming for the middle ground of pragmatism.

The Lustron Home

One product which attempted to solve such "housing problems" from an entirely different tack was the Lustron Home: a macro-modular, factory mass-produced, truck-delivered house of standardized components, built entirely from war surplus steel, primarily assembled off-site in a massive factory. The Lustron Home went further than any contemporary project toward entirely manufacturing housing via mass-production, in the mould of the automobile, falling just short of success. Between 1946 and 1948, when the company was forced into insolvency, Lustron received orders for 20,000 homes and built over 2500. More than 2000 exist still today *(fig. 12)*.[75]

Spearheaded by the industrialist Carl Strandlund and designed by the Boston-area architect Carl Koch, The Lustron homes included large picture windows like conventional houses, various rooms providing excellent views and light, built-in appliances, and availability in multiple colors.[76] With a mild ranch-style appearance, they were advertised primarily via high-tech

features: dishwashers and washing machines in the deluxe version (rare in 1946), radiant panel heating, and electric windows able to open and close with a switch. Not every advertised feature was utilitarian: a contemporary brochure calls attention to the "interior colors… designed to make furnishing and decorating easy. Neutral shades permit the widest possible variation in choice of draperies, rugs, and individual decorating schemes."[77] Such promotion seems definitively pointed at the average prospective homeowner, and not only toward their practical inclinations.

Each home was proudly etched with a model and serial number on a metal plaque. The promise of steel included sturdier construction and reduced maintenance. They were pitched as rodent-proof, fire-proof, lightning-proof and rust-proof (important points for a metal home), as well as being maintenance-free.[78] They were available in several sizes, and add-on module packages were available, including garages and breezeways.[79] Lustrons were available for viewing in at least one Newark department store,[80] and exemplified a new way of selling houses, that is, as collection of features like an automobile, shopped for in catalogs or in showrooms *(fig. 13)*.

Koch considered the modularity of the Lustron as one of its defining characteristics, the project's best chance for success: "In general we had reduced the complexity of parts, and as a result the size and complexity of machinery that would fabricate them. We had substantially increased their interchangeability. We had much increased the variety of plans from which the individual buyer might choose, and reduced the price he should have to pay for it."[81]

The vertical organization of the Lustron operation, that is, the planning for all stages of construction from raw materials to delivery, owed a great debt to the automotive industry. Production was a large-scale operation. With the use of a Chicago automobile plant, used during the war to produce B-29 aircraft engines, and a projected 26,000 employees when at full capacity,

Strandlund put together an assembly line based directly on techniques employed in the automobile sector, including gigantic stamping presses and cutting-edge porcelain enameling furnaces. Upon completion, all the parts necessary for a house were loaded on a specially-designed semi-trailer, which were then unloaded on-site in reverse order of construction need *(fig. 14)*. A complete and functional house could be built in 360 man-hours of on-site labor, that is, in three weeks with a minimum three-man crew.[82]

The design of the Lustron was a direct result of the architect's need for modularity, ease of construction and erection, as well as shrewd market considerations. As Knerr mentions, "the inherent efficiency of the ranch style represented modularity and modernity, a reduction of housing to its most essential features without sacrificing livability. It looked good in many orientations and could accommodate a range of interior plans in line with emerging consumer tastes."[83] Throughout the life of the Lustron Corporation and up to the present, inhabitants of Lustron homes routinely have professed their appreciation for the quality and durability of the structures. Enthusiasm at their inception was palpable: the Federal Housing Authority, initially reluctant to finance such an unconventional housing solution, was eventually pushed by popular demand to float a loan of $12.5 million.[84] By 1946, when Strandlund managed to erect a prototype Lustron in Hinsdale, Illinois, the house was visited by thousands of visitors, and was immediately purchased by the owners of the property.[85]

Eventually, however, the Lustron company failed, like most other vertical-market prefabricated housing enterprises of the day. In 1948, the Republican party retook Congress, and government spending came under renewed scrutiny. *Time* magazine concurrently published a piece on the Lustron, publicizing how public funds were supporting an unprofitable private company.[86] Like the Packaged House, the Lustron had missed the boat; the postwar housing boom came and went, and Lustron had not yet managed critical mass.

Why did the Lustron fail? I submit that with any organization the size of the Lustron Corporation, the reasons must be complex. Funding problems were certainly part of the problem: the major investor in Lustron was the United States Government. Bad press, building codes, and intrusive politics played rôles in this dissolution, to various degrees. Primarily, however, despite its conservative aesthetics, the Lustron was trying for nothing less than complete revolution in a conservative industry: it had far too ambitious a project, with well-entrenched enemies and public preconceptions. Besides the apparent enthusiasm in the trade press and among the informed public, consumers were still not ready for a radical redefinition of the home. A decade before the Lustron even was on the drawing table, John Burchard, an architectural engineer and professor at MIT, considered the essential problem, which, despite the housing boom after the war, still remained:

> Shall we redesign our product so radically that it is a new product, or shall we go through the process of slow growth? The answer to the first alternative, as evidenced by all the serious proposals, seems to be no. Only one man, Mr. Buckminster Fuller, with his Dymaxion house, has proposed a radical redesign of shelter, a really new product. And he describes his position as "an attitude…" there is no valid reason to suppose that the result, in the face of sales resistance entrenched in tradition, would be happy.[87]

The Lustron Home displayed conclusively that the housing industry is not like making automobiles. After all, when automobiles were first manufactured, they were competing not with established, entrenched competition, but with horse-drawn carriages. The housing industry is a more complex societal structure, in form and function: a car has one use, a house has many; a car leaves the factory ready to go, a house needs to be constructed or finished on site; a house requires foundations, connection to utility interfaces, graded land and landscaping. In 1935, a car could be financed in 12-18 months, while a house would take from 10-25 years.[88] A house, by nature, symbolizes and reinforces sober planning and risk-aversion: the acquisition of a house is

often a family's major ambition, in pursuit of which they spend decades. As Herbert explains, according to the conservative building industry, the primary function of a home is to "protect privacy, family life, cultural and social values, traditions."[89] In the United States at least, these qualities, for better or worse, seem to discourage radical new solutions, no matter how extraordinary. Where is no intrinsic relationship between housing and conservative taste, in the United States the historical entrenchment of conservative building styles and established manufacturing methods can outweigh novel solutions.

Conclusion

A recursive problem arises today when considering, in the twenty-first century, the outlook of modular and prefabricated housing. The Lustron example shows in stark relief that a system aiming for broad acceptance and appeal cannot be adopted in isolation: for prefabricated housing to catch hold, it may need to happen everywhere at once. Nothing less than a complete paradigm shift is necessary. On the other hand, industrial production, with the enormous costs and risks involved, seems the exact opposite of a sudden force: it tends to react to consumer demand.

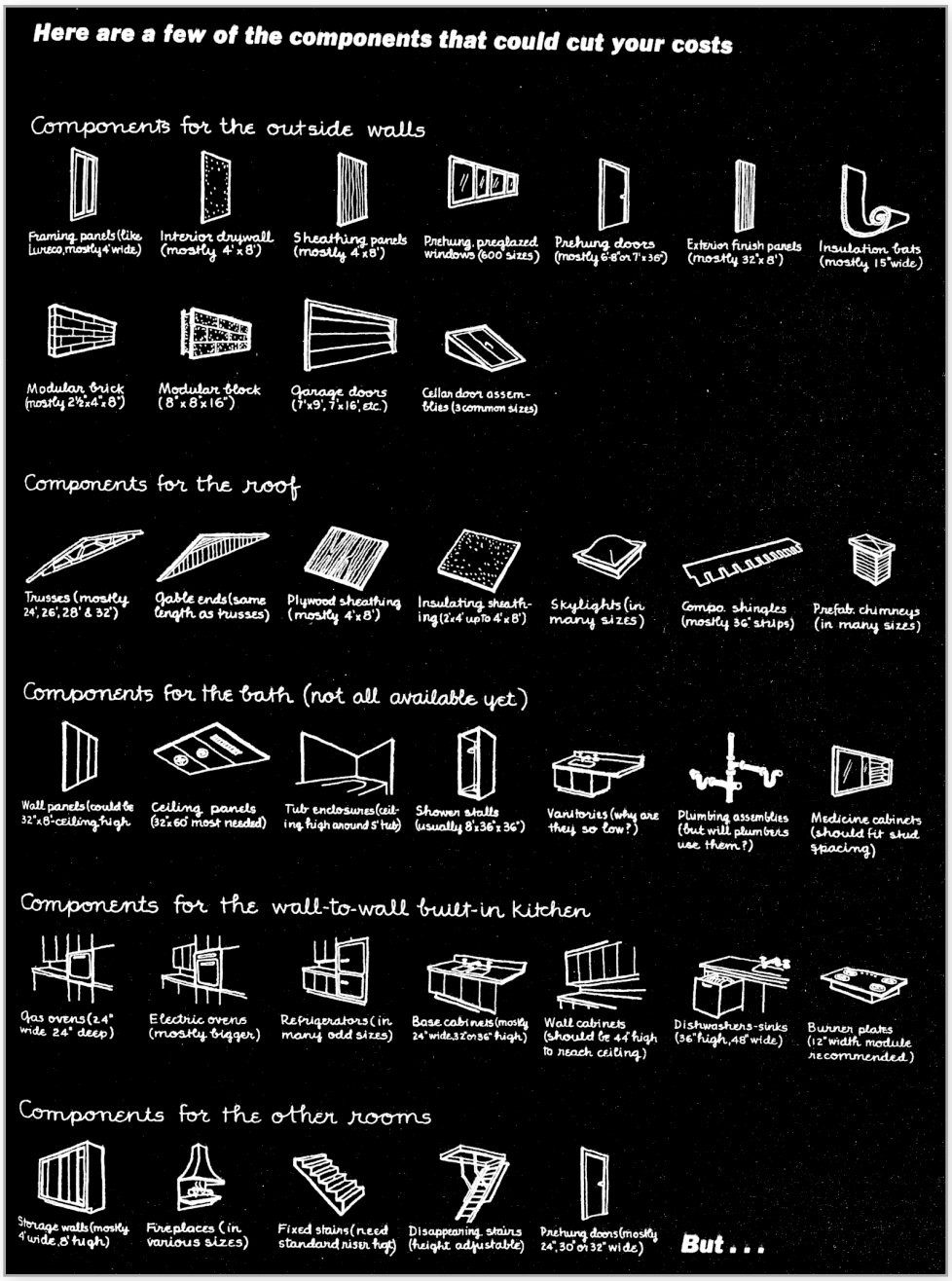
Prefabricated construction is ubiquitous these days: buildings of all sizes are built quickly in the field from standard components; a house can be constructed with parts available at the local big-box hardware store. Modules, too, are part of the common experience, showing up in everything from IKEA furniture, to Lego toys, to microchips. Modules and prefabrication are used extensively in all types of architecture, from the meanest flat to the tallest skyscraper. Why, then, with all of this energy and development, has the mail-order home failed to catch on? Why has there not been a real successor to the Lustron, or the Packaged House? Why is Buckminster Fuller regarded with such deference, while his Dymaxion houses and geodesic domes are viewed with something of an alien curiosity, without anything approaching broad societal implementation?

Short of denying the aesthetic power of Fuller's creations, or the functionalism inherent in a well-designed Wright house, it seems neither architect used the module or prefabrication to its full potential. Eames and Saarinen may have managed somewhat better, in part due to the halo of popularity which surrounded the Case Study homes at the time of their inception. Their work had another element, however, to which I've endeavored to allude: the Eames/Saarinen house stoked the public imagination via how well it fulfilled its purpose, but also, in equal measure, by how it *felt*. It struck a balance between function and form: neither followed the other. If a Lustron home, or its equivalent, is to succeed today, it must do both, at once satisfying the need for a well-functioning "machine for living", while being appealing and comfortable to inhabit.

I do not ascribe to a return to formalism: this is not an argument for abandoning any functional asset in favor of any style. That split may definitively mark a modernist sensibility. Today's challenge is instead to reconcile such absolutes within our contemporary context. For the *machine à habiter* to succeed, form must not follow function: the two are inextricably linked, and each cannot be championed in isolation.

Illustrations

Fig. 1



Modular fixtures for home construction.

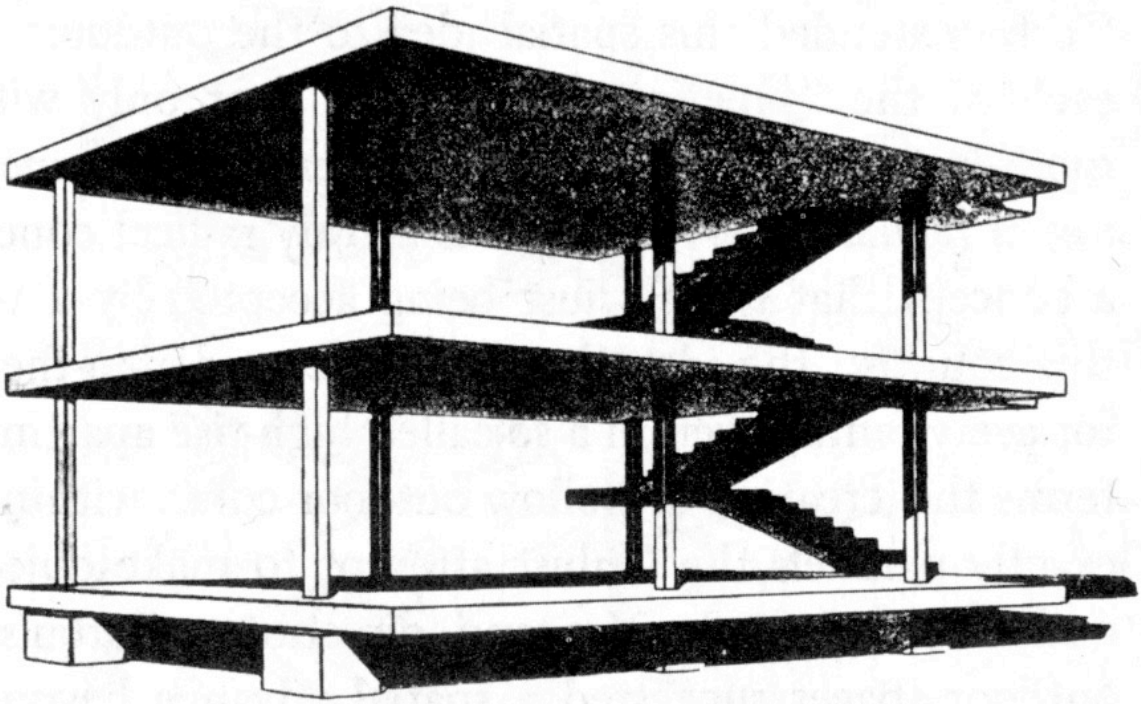
J. André Fouilhoux, "Prefabricated Units for the Home," *Architectural Forum*, December 1935: 552.

Fig. 2

Levittown, Pennsylvania, aerial view, c. 1959.

Alexander Phillips, "Levittown, Pennsylvania," Blog, *The Urban Times*, September 30, 2010 http://www.theurbn.com/2010/09/levittown-urban-revitalization/levittownpennsylvania/.

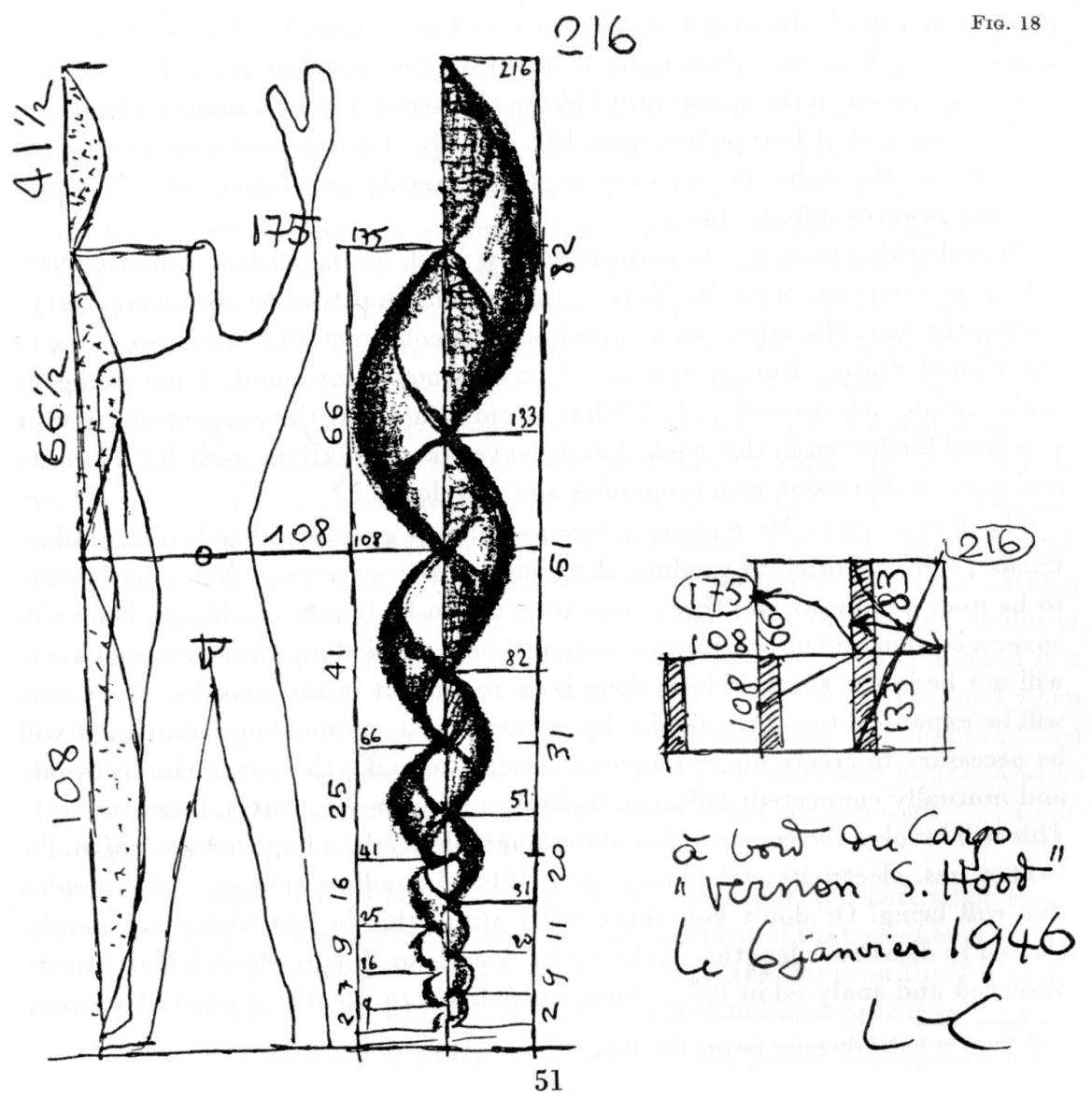
Fig. 3



Design for Le Corbusier's Dom-ino House, an early example of prefabricated architecture.

Peter Blake, *The Master Builders: Le Corbusier, Mies van der Rohe, Frank Lloyd Wright* (New York: Norton, 1976), 39.

Fig. 4



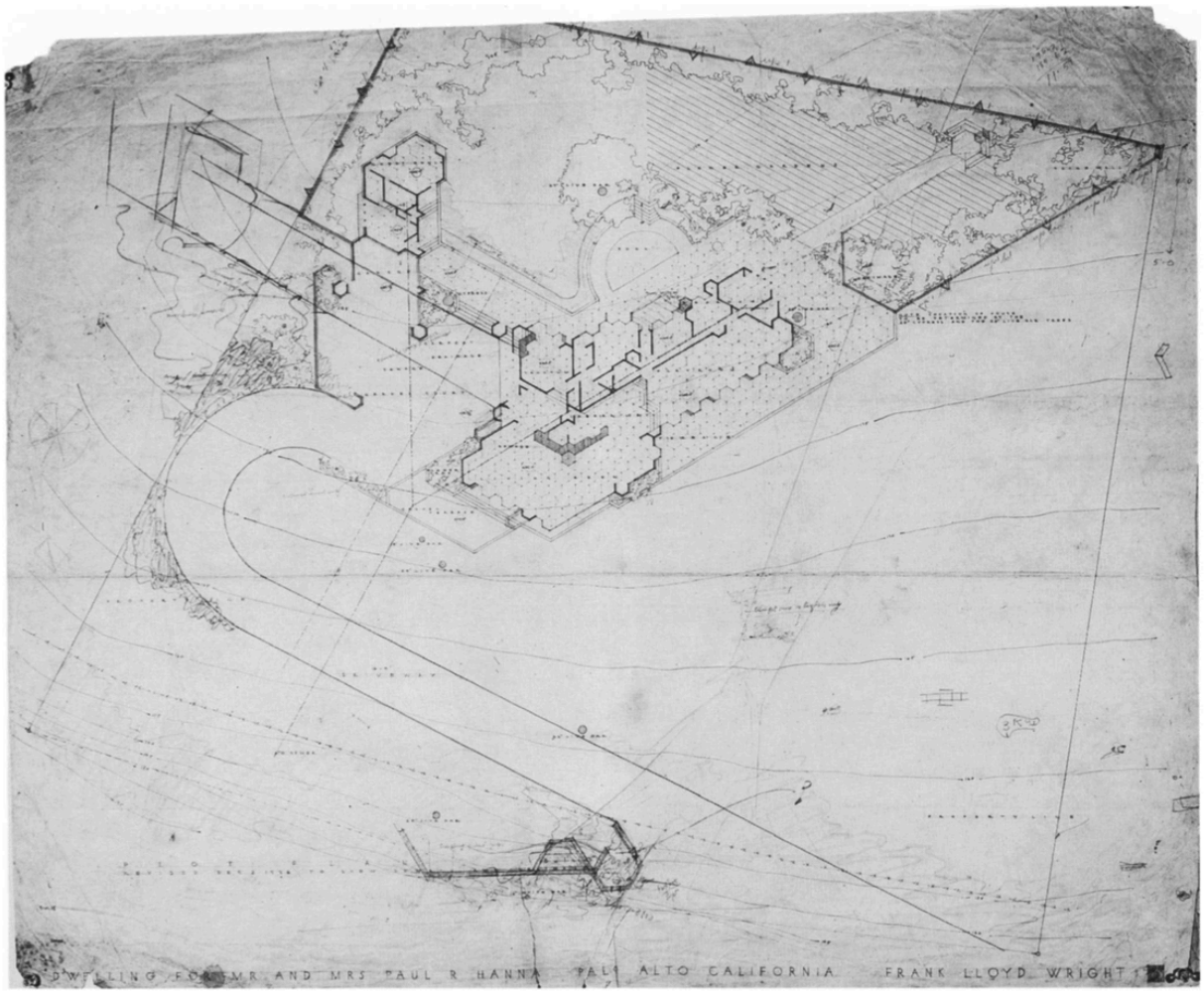
According to Le Corbusier, modules derive from the human body.

Le Corbusier, *The Modulor: a harmonious measure to the human scale, universally applicable to architecture and mechanics* (Basel: Birkhäuser, 2000), 51.

Fig. 5

Gerrit Rietveld *(Dutch, 1888-1964)*, *Red Blue Chair*, 1923
Painted wood, 34 1/8 x 26 x 33“, seat h. 13”
Museum of Modern Art, New York, http://www.moma.org/collection/browse_results.php?object_id=4044.

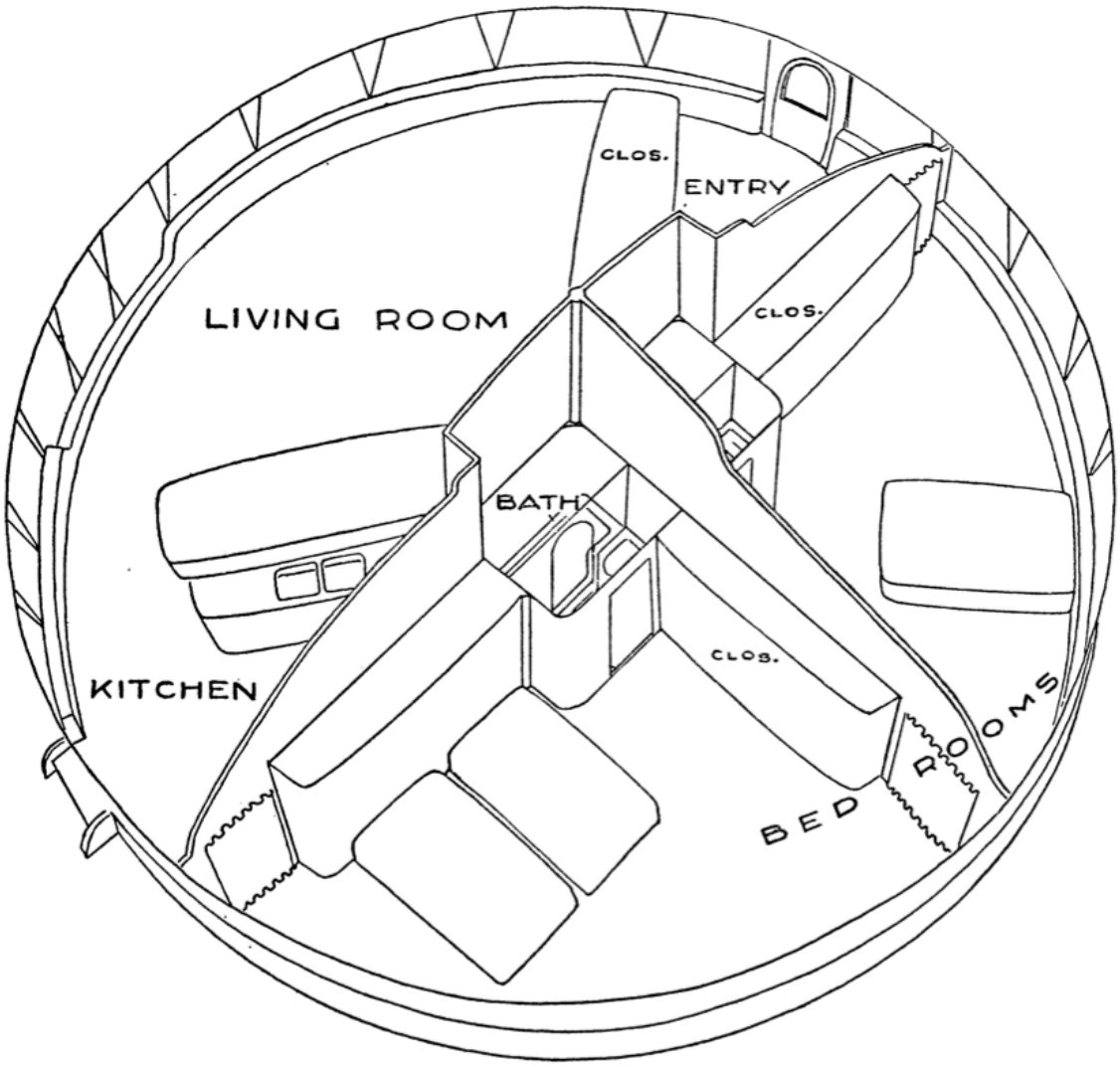
Fig. 6



Wright preferred a hexagonal module.

Richard Joncas, "Pedagogy and 'Reflex': Frank Lloyd Wright's Hanna House Revisited," *Journal of the Society of Architectural Historians* 52, no. 3 (September 1993): 314.

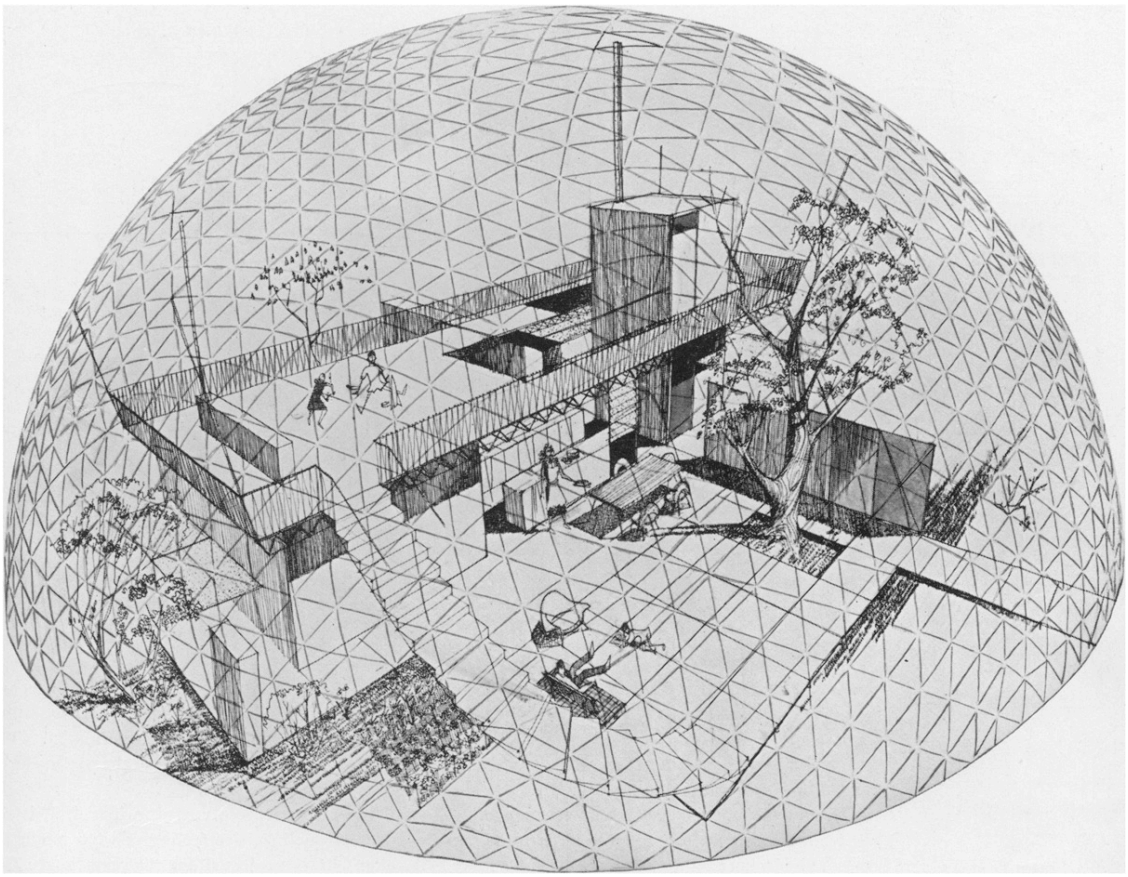
Fig. 7



Floorplan of Fuller's Dymaxion House.

Clay Lancaster, "Transportation Design Elements in American Architecture," *American Quarterly* 8, no. 3 (Autumn 1956): 217.

Fig. 8



Fuller's Geodesic Dome. Both the dome and the house underneath adhere to modular systems.

Buckminster Fuller, "Buckminster Fuller," *Perspecta* 1 (Summer 1952): 35.

Fig. 9

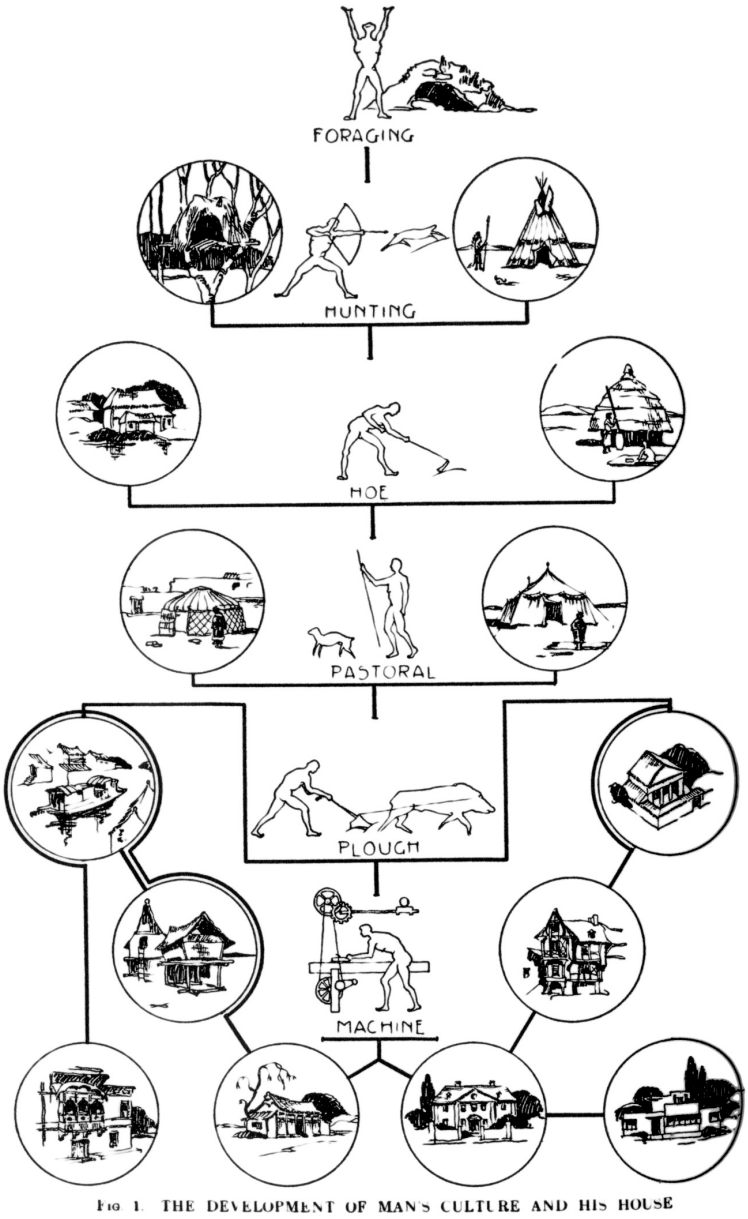
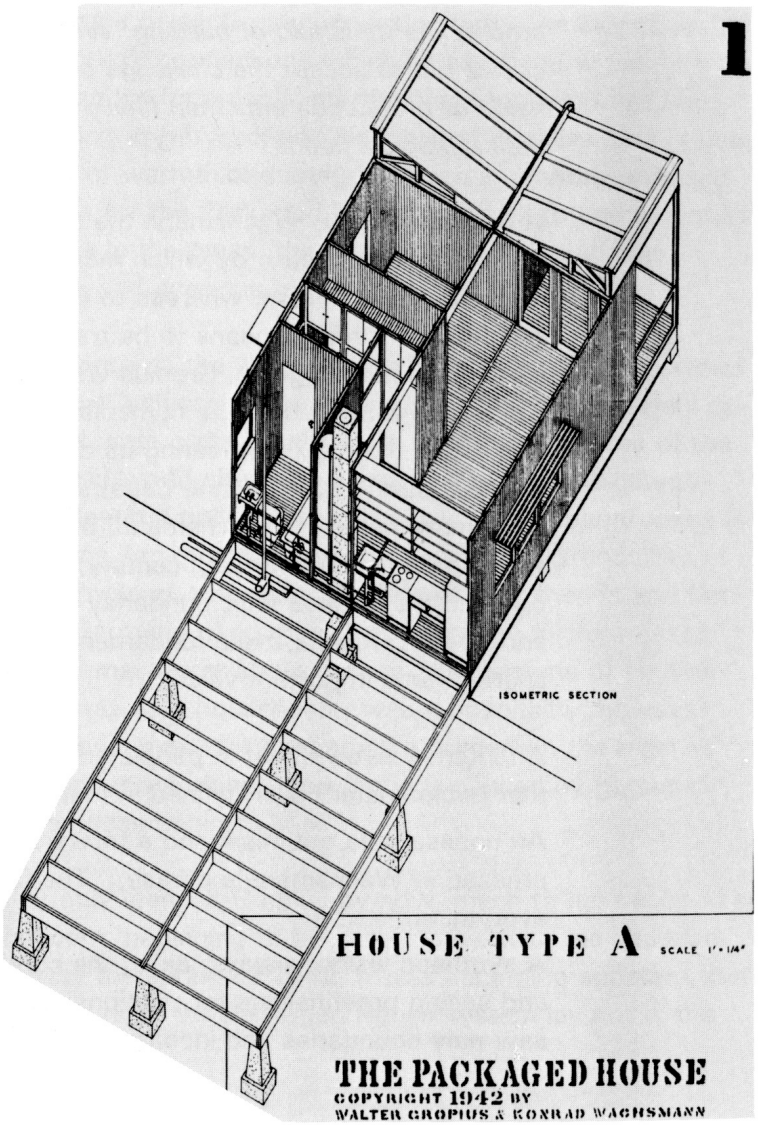


FIG. 1. THE DEVELOPMENT OF MAN'S CULTURE AND HIS HOUSE

The Bemis Progression.

Albert Farwell Bemis and John E. Burchard, *The Evolving House* (Cambridge, MA: Massachusetts Institute of Technology, 1933): 45.

Fig. 10



One configuration of Gropius and Wachsmann's Packaged House.

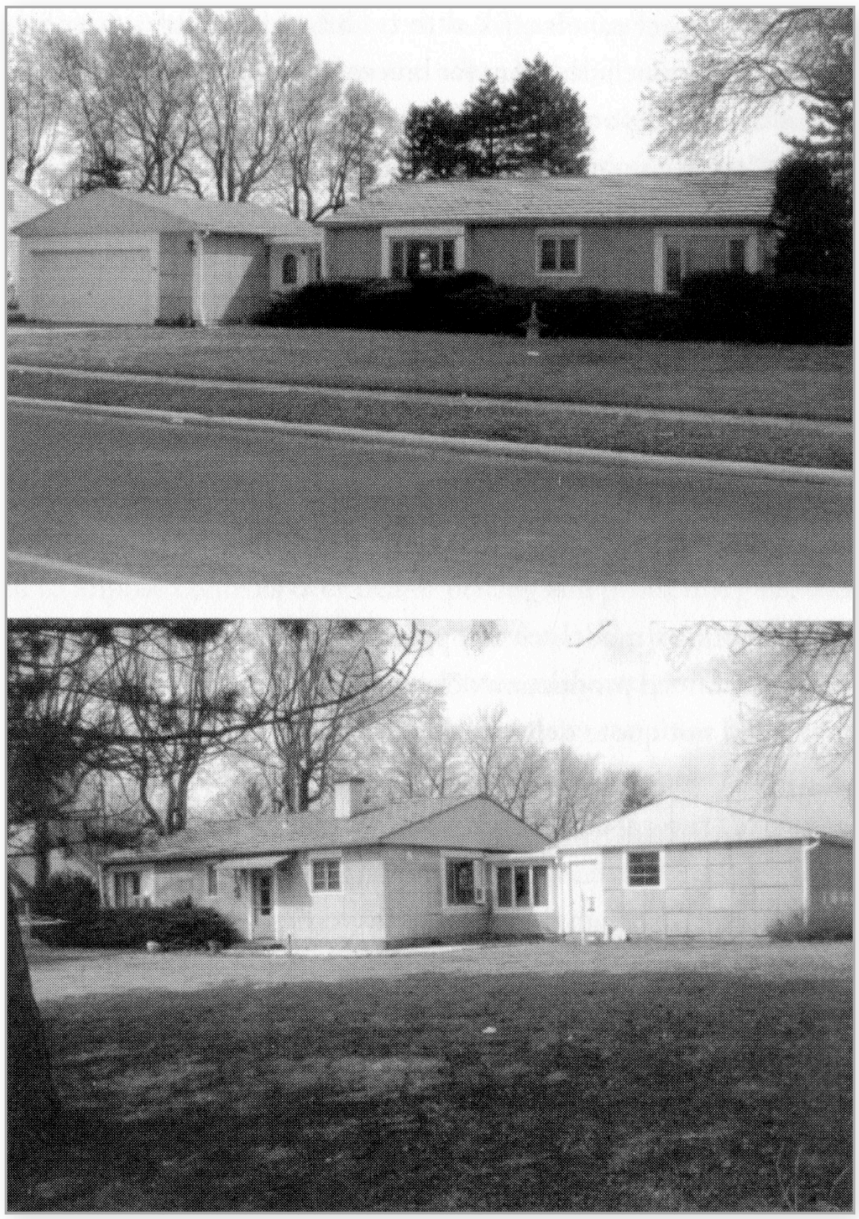
Gilbert Herbert, *The Dream of the Factory-Made House: Walter Gropius and Konrad Wachsmann* (Cambridge, London: Massachusetts Institute of Technology, 1984).

Fig. 11

Case Study House #8, by Charles Eames and Eero Saarinen (later the residence of Charles and Ray Eames).

Art & Architecture Magazine, "Case Study House for 1949" (Art & Architecture Magazine, 1949), http://www.artsandarchitecture.com/case.houses/houses.html.

Fig 12



Exterior views of the Lustron House, front and back, with garage module installed.

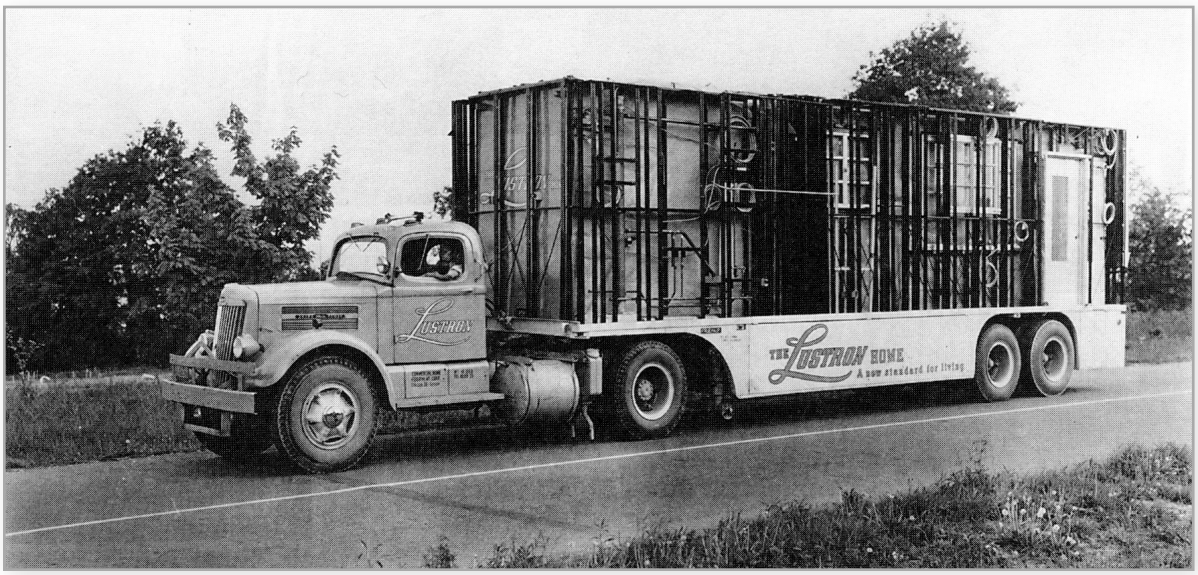
Douglas Knerr, *Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951* (Columbus, OH: Ohio State University, 2004): 151.

Fig. 13

Lustron Newspaper Advertisement.

Tom Wolfe and Leonard Garfield, "'A New Standard for Living': The Lustron House, 1946-1950," *Perspectives in Vernacular Architecture* 3 (1989): 59.

Fig. 14



Delivering the Lustron Home.

Douglas Knerr, *Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951* (Columbus, OH: Ohio State University, 2004): 151.

Bibliography

Anderson, Lawrence B. "The Architect in the Next Fifty Years." *Journal of Architectural Education* 14, no. 1 (Spring 1959): 3-9.

Art & Architecture Magazine. "Case Study House for 1949". Art & Architecture Magazine, 1949. Art & Architecture Magazine Website. http://www.artsandarchitecture.com/case.houses/houses.html.

Barr, Alfred H. Jr., Henry Russel Hitchcock, Walter Gropius, George Nelson, Ralph T. Walker, Christopher Tunnard, Frederick Gutheim, et al. "What Is Happening to Modern Architecture?: A Symposium at the Museum of Modern Art." *The Bulletin of the Museum of Modern Art* 15, no. 3 (Spring 1948): 4-20.

Bell, Jonathan, and Sally Godwin. *The transformable house*. Chichester, UK: Wiley-Academy, 2000.

Bemis, Albert Farwell, and John E. Burchard. *The Evolving House*. Cambridge, MA: Massachusetts Institute of Technology, 1933.

Blake, Peter. *The Master Builders: Le Corbusier, Mies van der Rohe, Frank Lloyd Wright*. New York: Norton, 1976.

Brown, Theodore M. "Rietveld's Egocentric Vision." The Journal of the Society of Architectural Historians 24, no. 4 (December 1965): 292-296.

Buisson, Ethel, and Thomas Billard. The presence of the case study houses. Basel: Birkhäuser, 2004.

Burchard, John Ely. "Prefabricated Housing and Its Marketing Problems." *American Marketing Journal* 2, no. 3 (July 1935): 150-156.

Bush, Donald J. "Streamlining and American Industrial Design." *Leonardo* 7, no. 4 (Autumn 1974): 309-317.

Colean, Miles L. "What is the Engineered House?" *House Beautiful*, November 1947.

Dennis, James M., and Lu B. Wenneker. "Ornamentation and the Organic Architecture of Frank Lloyd Wright." *Art Journal* 25, no. 1 (Autumn 1965): 2-14.

Eames, Charles, and Eero Saarinen. "Case Study House: A House Designed and Built for the Magazine Arts & Architecture". Arts & Architecture Magazine, 1946. http://www.artsandarchitecture.com/case.houses/pdf01/09.pdf.

Editors of Arts & Architecture Magazine. "The Case Study House Program." *Arts & Architecture*, January 1945.

Fetters, Thomas T., and Vincent Kohler. *The Lustron home: the history of a postwar prefabricated housing experiment.* Jefferson, NC: McFarland, 2002.

Fitch, James Marston. "The Rise of Technology: 1929-1939." *Journal of the Society of Architectural Historians* 24, no. 1 (March 1965): 75-77.

Fouilhoux, J. André. "Prefabricated Units for the Home." *Architectural Forum*, December 1935.

Fuller, Buckminster. "Buckminster Fuller." *Perspecta* 1 (Summer 1952): 28-37.

———. "The Cardboard House." *Perspecta* 2 (1953): 28-35.

Giedion, Siegfried. *Space, time, and architecture: the growth of a new tradition*. 3rd ed. The Charles Eliot Norton lectures for 1938-1939. Cambridge, MA: Harvard University Press, 1954.

Goodman, Paul. "Frank Lloyd Wright on Architecture." *The Kenyon Review* 4, no. 1 (Winter 1942): 7-28.

Hatch, Alden. *Buckminster Fuller: at home in the universe.* New York: Crown Publishers, 1974.

Herbert, Gilbert. *The Dream of the Factory-Made House: Walter Gropius and Konrad Wachsmann.* Cambridge, London: Massachusetts Institute of Technology, 1984.

Hitchcock, Henry Russel, and Philip Johnson. *The International Style*. New York: Norton, 1995.

Joncas, Richard. "Pedagogy and 'Reflex': Frank Lloyd Wright's Hanna House Revisited." *Journal of the Society of Architectural Historians* 52, no. 3 (September 1993): 307-322.

Kelly, Burnham. *The prefabrication of houses: a study by the Albert Farwell Bemis Foundation of the prefabrication industry in the United States*. Cambridge, MA and New York: Massachusetts Institute of Technology and Wiley, 1951.

Knerr, Douglas. *Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951.* Columbus, OH: Ohio State University, 2004.

Lancaster, Clay. "Transportation Design Elements in American Architecture." *American Quarterly* 8, no. 3 (Autumn 1956): 199-215.

Le Corbusier. *The Modulor II: Let the User Speak Next*. Basel: Birkhäuser, 2000.

———. *The Modulor: a harmonious measure to the human scale, universally applicable to architecture and mechanics.* Basel: Birkhäuser, 2000.

———. *Towards a new architecture*. London: J. Rodker, 1931.

The Lustron Corporation. "Things you want to know about the Lustron Home." The Lustron Corporation, c. 1945. *Lustron Preservation Website*. http://www.lustronpreservation.org/wp-content/uploads/2007/12/0000-lustron-corporation-brochure-know.pdf.

Marks, Robert W. *The Dymaxion world of Buckminster Fuller.* New York: Reinhold, 1960.

Mitchell, Robert A. "What Ever Happened to Lustron Homes?" *APT Bulletin* 23, no. 2 (1991): 44-53.

Myers, Howard. "The Standardized House." *Architectural Forum*, September 1938.

Phillips, Alexander. "Levittown, Pennsylvania." Blog. *The Urban Times*, September 30, 2010. http://www.theurbn.com/2010/09/levittown-urban-revitalization/levittownpennsylvania/.

Pyron, Bernard. "Wright's Diamond Module Houses: His Development of Non-Rectilinear Interior Space." *Art Journal* 21, no. 2 (Winter 1961): 92-96.

Reickert, Judy. "The Story Of Lustron Homes." *Lustron Connection*, n.d. http://www.lustronconnection.org/.

Smiley, David. "Making the Modified Modern." *Perspecta* 32, no. Resurfacing Modernism (2001): 38-54.

Smith, Elizabeth A. T., and Esther McCoy. *Blueprints for modern living: history and legacy of the case study houses*. Los Angeles: Museum of Contemporary Art, 1989.

Wachsmann, Konrad. *The Turning Point of Building: Structure and Design*. Translated by Thomas E. Burton. New York: Reinhold, 1961.

Walker Art Center. "Richard Buckminster Fuller." *Design Quarterly* 74/75, Process and Imagination (1969): 22-24.

Weiner, E. S. C., with Simpson, J. A., Oxford University Press. *The Oxford English Dictionary*. Oxford, UK: Oxford University Press, 2009.

Wolfe, Tom, and Leonard Garfield. "'A New Standard for Living': The Lustron House, 1946-1950." *Perspectives in Vernacular Architecture* 3 (1989): 51-61.

Wright, Frank Lloyd. *An Autobiography*. London: Faber and Faber, 1946.

Endnotes

1 Gilbert Herbert, *The Dream of the Factory-Made House: Walter Gropius and Konrad Wachsmann* (Cambridge, London: Massachusetts Institute of Technology, 1984): 38-39.

2 J. André Fouilhoux, "Prefabricated Units for the Home," *Architectural Forum*, December 1935.

3 Albert Farwell Bemis and John E. Burchard, *The Evolving House* (Cambridge, MA: Massachusetts Institute of Technology, 1933).

4 Konrad Wachsmann, *The Turning Point of Building: Structure and Design*, trans. Thomas E. Burton (New York: Reinhold, 1961).

5 Herbert, *The Dream of the Factory-Made House.*

6 Ibid., 30.

7 E. S. C. Weiner, with J. A. Simpson, Oxford University Press, *The Oxford English Dictionary* (Oxford, UK: Oxford University Press, 2009).

8 Le Corbusier, *Towards a new architecture* (London: J. Rodker, 1931).

9 Ibid., 6.

10 Le Corbusier, *The Modulor: a harmonious measure to the human scale, universally applicable to architecture and mechanics* (Basel: Birkhäuser, 2000).

11 Ibid., 5.

12 Lawrence B. Anderson, "The Architect in the Next Fifty Years," *Journal of Architectural Education* 14, no. 1 (Spring, 1959): 8.

13 Le Corbusier, *The Modulor*: 6.

14 Ibid., 33.

15 Henry Russel Hitchcock and Philip Johnson, *The International Style* (New York: Norton, 1995):70.

16 Theodore M. Brown, "Rietveld's Egocentric Vision," *The Journal of the Society of Architectural Historians* 24, no. 4 (December 1965): 294.

17 Ibid., 294.

18 Ibid., 294.

19 Ibid., 294.

20 Ibid., 294.

21 Bernard Pyron, "Wright's Diamond Module Houses: His Development of Non-Rectilinear Interior Space," *Art Journal* 21, no. 2 (Winter, 1961): 95.

22 Pyron, "Wright's Diamond Module Houses," 95-96.

23 Richard Joncas, "Pedagogy and 'Reflex': Frank Lloyd Wright's Hanna House Revisited," *Journal of the Society of Architectural Historians* 52, no. 3 (September 1993): 307-322.

24 Ibid., 308.

25 Ibid., 313.

26 Ibid., 313.

27 Bernard Pyron, "Wright's Diamond Module Houses," 93.

28 Paul Goodman, "Frank Lloyd Wright on Architecture," The Kenyon Review 4, no. 1 (Winter 1942): 7-28.

[29] James M. Dennis and Lu B. Wenneker, "Ornamentation and the Organic Architecture of Frank Lloyd Wright," *Art Journal* 25, no. 1 (Autumn 1965): 2-14.

[30] Frank Lloyd Wright, *An Autobiography* (London: Faber and Faber, 1946): 201.

[31] Donald J. Bush, "Streamlining and American Industrial Design," *Leonardo* 7, no. 4 (Autumn 1974): 309.

[32] Alden Hatch, *Buckminster Fuller: at home in the universe* (New York: Crown Publishers, 1974): 80-86.

[33] Bush, "Streamlining and American Industrial Design," 313.

[34] Ibid., 313.

[35] Buckminster Fuller, "Buckminster Fuller," *Perspecta* 1 (Summer 1952): 29.

[36] Jonathan Bell and Sally Godwin, *The transformable house* (Chichester, UK: Wiley-Academy, 2000): 17.

[37] Walker Art Center, "Richard Buckminster Fuller," *Design Quarterly* 74/75, no. Process and Imagination (1969): 23.

[38] Fuller, "Buckminster Fuller," 27.

[39] Clay Lancaster, "Transportation Design Elements in American Architecture," *American Quarterly* 8, no. 3 (Autumn): 215.

[40] Peter Papademetriou, "Coming of Age: Eero Saarinen and Modern American Architecture," *Perspecta* 21 (1984): 121.

[41] Fuller, "Buckminster Fuller," 31.

[42] Ibid., 30.

[43] J. André Fouilhoux, "Prefabricated Units for the Home," *Architectural Forum*, December 1935: 544.

[44] Ibid., 27.

[45] Herbert, *The Dream of the Factory-Made House*: 223.

[46] James Marston Fitch, "The Rise of Technology: 1929-1939," *Journal of the Society of Architectural Historians* 24, no. 1 (March 1965): 75.

[47] Fuller, "Buckminster Fuller," 36.

[48] J. André Fouilhoux, "Prefabricated Units for the Home," 191.

[49] Ibid., 189.

[50] Ibid., 196.

[51] Miles L. Colean, "What is the Engineered House?," *House Beautiful*, November 1947: 191.

[52] Herbert, *The Dream of the Factory-Made House*: 20.

[53] Douglas Knerr, *Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951* (Columbus, OH: Ohio State University, 2004): 44

[54] John Ely Burchard, "Prefabricated Housing and Its Marketing Problems," *American Marketing Journal* 2, no. 3 (July 1935): 151.

[55] Ibid., 150.

[56] James Marston Fitch, "The Rise of Technology: 1929-1939," *Journal of the Society of Architectural Historians* 24, no. 1 (March 1965): 77.

[57] Herbert, *The Dream of the Factory-Made House:* 164.

[58] Burchard, "Prefabricated Housing and Its Marketing Problems," 150.

[59] Herbert, *The Dream of the Factory-Made House*:: 7-8.

[60] Alfred H. Jr. Barr et al., "What Is Happening to Modern Architecture?: A Symposium at the Museum of Modern Art," *The Bulletin of the Museum of Modern Art* 15, no. 3 (Spring): 4-20.

[61] Herbert, *The Dream of the Factory-Made House*: 38.

[62] Ibid., 41.

[63] Herbert, *The Dream of the Factory-Made House*: 63.

[64] Barr, "What Is Happening to Modern Architecture," 4-20.

[65] David Smiley, "Making the Modified Modern," *Perspecta* 32, Resurfacing Modernism (2001): 42.

[66] Ibid., 44.

[67] Herbert, *The Dream of the Factory-Made House*: 9.

[68] Ibid., 259.

[69] Ibid., 256

[70] Ibid., 256

[71] Ibid., xi-xii.

[72] Papademetriou, "Coming of Age: Eero Saarinen and Modern American Architecture," 121.

[73] Ibid., 121.

[74] Editors of Arts & Architecture Magazine, "The Case Study House Program," *Arts & Architecture*, January 1945: 38.

[75] Thomas T. Fetters and Vincent Kohler, *The Lustron home: the history of a postwar prefabricated housing experiment* (Jefferson, NC: McFarland, 2002): 1.

[76] Judy Reickert, "The Story Of Lustron Homes," *Lustron Connection*, n.d., http://www.lustronconnection.org/.

[77] The Lustron Corporation, "Things you want to know about the Lustron Home." (The Lustron Corporation, c. 1945), Lustron Preservation Website, http://www.lustronpreservation.org/wp-content/uploads/2007/12/0000-lustron-corporation-brochure-know.pdf.

[78] Ibid.

[79] Robert A. Mitchell, "What Ever Happened to Lustron Homes?," *APT Bulletin* 23, no. 2 (1991): 47.

[80] Judy Reickert, "The Story Of Lustron Homes."

[81] Douglas Knerr, *Suburban Steel: The Magnificent Failure of the Lustron Corporation, 1945-1951* (Columbus, OH: Ohio State University, 2004): 150.

[82] Robert A. Mitchell, "What Ever Happened to Lustron Homes?," 46-47.

[83] Douglas Knerr, *Suburban Steel*: 78

[84] Robert A. Mitchell, "What Ever Happened to Lustron Homes?," 46.

[85] Ibid., 46.

[86] Fetters and Kohler, *The Lustron home:* 85.

[87] Burchard, "Prefabricated Housing and Its Marketing Problems,"152.

[88] J. André Fouilhoux, "Prefabricated Units for the Home," 544.

[89] Gilbert Herbert, *The Dream of the Factory-Made House*: 19.