The Kit of Parts as Medium and Message for Developing Post-War Dwellings

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ABSTRACT

Since the construction of the "Crystal Palace" by Joseph Paxton in 1851, the manufactured component became the basis for the efficient production of architecture. Making buildings from a kit of parts is a manifestation of a series of interrelated themes in architecture and its writings emerging and evolving from the mid nineteenth to the mid twentieth century: the converging of architecture with mass production, the transference of military expertise to civilian use and a search for new dwelling types for cold war subsistence. These concepts reformed construction and the industrialization of construction would parallel the advances made in commodity production. The revolution in manufacturing was accompanied by and magnified social transformations leading to an ever-increasing demand for affordable urban housing. This major growth contributed to one of architectural modernity's foremost quests: designing the post-war house. The modern dwelling echoed new architectural values and was the focal point of architectural literature in periodicals, planning and technical journals. The manufactured architectural kit, a tool for flexibility, adaptability, resilience and mobility, placed synchronized design and production along with affordability as its main selling points and became an emblem of innovative post-war dwelling schemes. Proposed by Walter Gropius in his infamous manifesto in 1909 and developed later with Konrad Wachsmann as "The Packaged House" (Herbert 1984), the kit of parts ideology infiltrated architecture's production. The manufactured kit symbolized a new era and would bring quality architecture to the masses. Along with a look back at its evolution, three significant productions showcase the kit as both medium and message for developing a post-war dwelling: *Arts and Architecture's* "Case Study House Program" and its influence in California and beyond, Buckminster Fuller's "Standard of Living Package" and plastic shell construction for the "House of the Future", not only portray the evolution of modernity through post-war American domesticity but also express the underlying theme of how kit architecture would realize the longstanding dream of the factory made house and even make a case for a kit of parts urbanism in the latter half of the twentieth century.

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Modern architecture in the United States; The Case Study House Program; Buckminster Fuller; Autonomous dwelling; Kit of parts; Prefabrication

1.0 Background

From colonisation to specialized catalogues, the kit of parts as a social construct

The kit of parts, prepared, sorted and tested in advance of building, is not a specifically modern invention. Many have described this type of prefabrication as the oldest new idea in architecture. The prefabrication paradigm in architecture is based on the experiments of many generations of builders. From Roman military engineers, to medieval master guilds and to Great Britain's early industrialists, all prepared components off-site (pre-cut stones, pre-cut or notched wooden beams, corrugated iron sheets) to facilitate on-site construction. The traditional Japanese house is perhaps the most emblematic of vernacular modular[1] kit building applied by sawyers and master carpenters as a way of simplifying construction and even providing for replacement parts in the event of earthquakes [Fig.1]. Rudofsky in *Architecture Without Architects* (1964) posits that prefabrication and standardization are primitive solutions that anticipated modern technology.

Industrial development proposed a new type of production in advance of construction. Components for buildings could be mass-produced and normalized to facilitate their assembly. Accompanied by urbanisation, colonisation and intensive resource harvesting, demand for housing systems increased creating a generative environment for the industrialization of construction. The "Iron Houses" delivered to Australia from Great Britain to accommodate the burgeoning population of gold rushers (National Trust 2012) or the precut timber houses delivered to colonies represent early forms of manufactured kit building applied to housing (Blanchet and Zhuravlyova 2018).

1. "…the use of these proportions (kiwarijutsu) enabled the carpenter-builder to achieve overall architectural harmony by basing the major measurements in his design on a few set of standards modules…" Nishi Kazuo and Kazuo Hozumi, *What is Japanese Architecture* (New York: Kodansha International, 1985), 76-77.

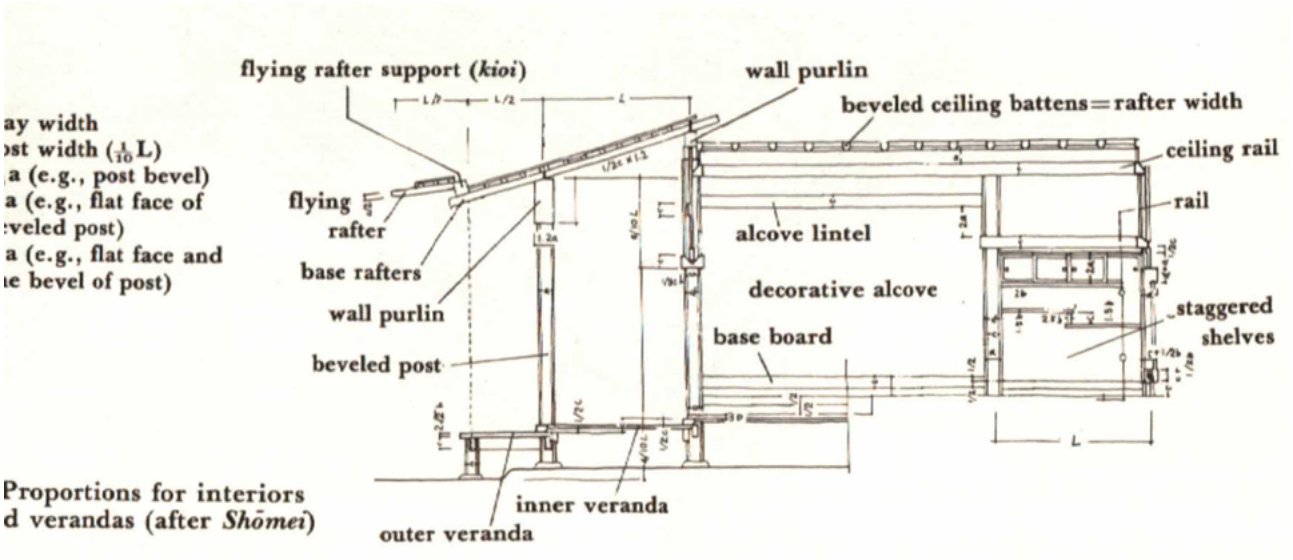


FIG. 1 A Japanese Modular kit. Source: Nishi K and Hozumi K (1985)

Specifically, in the USA, the amplification of growth during the nineteenth century intensified the harvesting of old growth forests and the operation of lumber mills as territorial development expanded. Advances in railroad transport and the mechanization of saw mills and iron nail cutting added to the efficiency with which industry progressed. Manufacturing precise pieces of lumber helped standardize export ready components for building. The American balloon frame generated from this industrialization of the forest industry contributed to the «do it yourself» building culture in America and subsequently throughout the developing world. The balloon frame became the prevailing quickly built, low-cost easy to communicate building system. Included in pattern books and catalogues used by master carpenters, the pattern books provided models and attested to their relevance. Burn (1877) published *The Details of an American Balloon Frame* showcasing that timber's dry assembly methods, notches and tight-fitting complex joinery were being replaced by quick and easy nailing [Fig. 2].

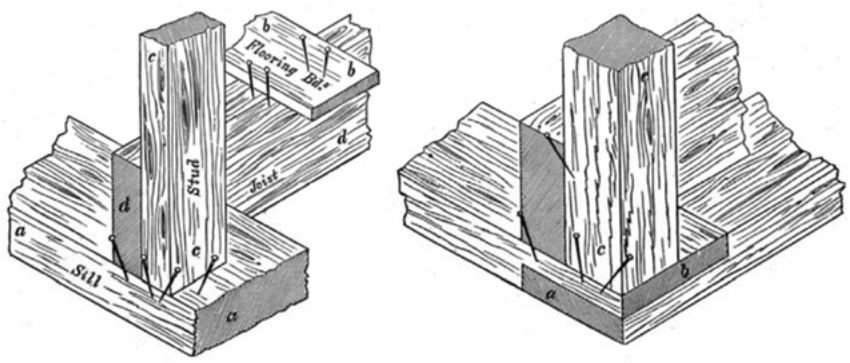


FIG. 2 Details of an American balloon frame. Source: Burn (1877)

From this easy to build culture spawned the design of specific housing kits where elements were simply precut and shipped for a quick onsite delivery. From the American Sears Roebuck catalogue house to the German Christof and Unmack system, the timber kit of parts, milled and sorted in a factory became representative of the manufactured house industry. Other notable companies, Alladin, Liberty and the German Huf Haus produced intelligible kits optimally packaged and delivered wherever the client wanted. Later, to increase efficiency, prefab housing producers turned to factory produced modular boxes and the kit of pre-cut parts became a peripheral strategy for prefabrication. The mobile home or volumetric manufactured house delivered on a trailer came to represent prefabrication in America.

The kit however remained the emblem of do-it-yourself flexibility. The Liberty "Ready-Cut House" in the USA typified the manufactured kit and is part of approximately 500 000 units produced in the United States during the pre and post-war housing crisis.[2] The Liberty house kit contained all the required lumber for structure, siding, mouldings and

2. "Liberty Ready Cut Homes Catalogue." Lewis Manufacturing Company, 1952. Accessed June 26,2019 https://archive.org/details/LibertyReady-cutHomes1952

FIG. 3 Liberty Catalogue Cover. Source: Author's collection

finishes. The bundled hardware included nails, screws, windows, doors, siding and easy to follow assembly instructions **[Fig. 3]**. The Liberty catalogue of multiple designs *"architecturally designed for simple living"*[3] were all based on a simple 2-by-4 frame structure for walls and short spans of 2-by floor joists and roof rafters. The simple to build 2-by-4 frame and the steel nail were the core components of an infinite architectural variability. Doors, windows, siding and built-in furniture were dimensionally coordinated and would adapt to any design. The pattern book of house types demonstrated the company's idea of customization and included an order form for a complete house kit delivered and labelled to optimize on-site assembly with or without a hired carpenter or builder.

3. "Liberty Ready Cut Homes Catalogue."

Probably the most famous, The Sears Roebuck catalogue, distributed from 1908, was not the first of its kind nor the most industrially advanced, as each model's components were simply pre-cut. Decades earlier, the D.N. Skillings and D.B. Flints[4] catalogue of sectional portable buildings proposed a nascent industrial building system. The catalogue of varied building plans proposed a system of panels, standardized on a set module, that could be packed, shipped and assembled with ease **[Fig.4]**.

4. "D.N. Skillings and D.B. Flint's Illustrated Catalogue of Portable Sectional Buildings" D.N. Skillings and D.B. Flint, 1861. Accessed June 26, 2019 https://archive.org/details/SkillingsFlintCCA196560

> *"The construction of these buildings is so simple that two or three men without mechanical knowledge or experience in building can*

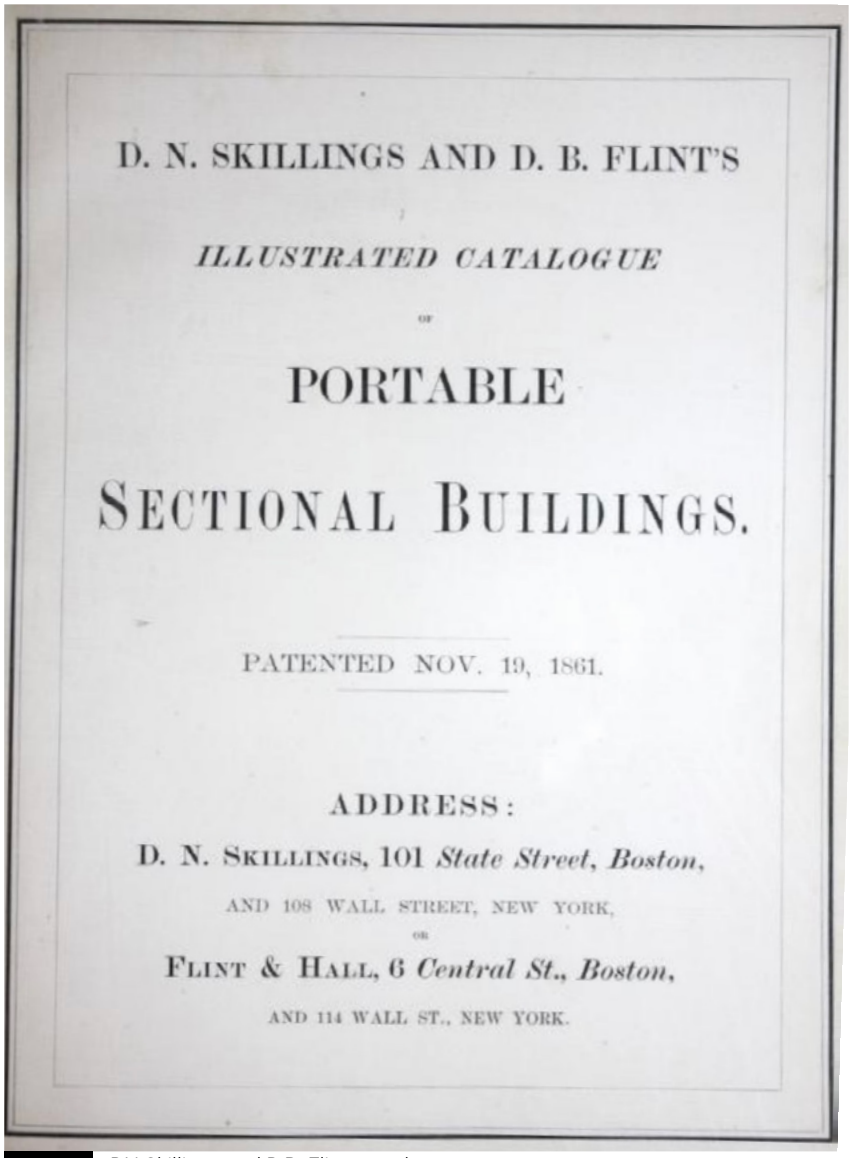
> *set up one of them in less than three hours and with equal ease the same men can take it down , remove it to another locality, and rebuild it without additional material."*[5]

5. "D.N. Skillings and D.B. Flint's Illustrated Catalogue of Portable Sectional Buildings"

This excerpt from the catalogue demonstrates the value already being placed on prefabrication at the time as a flexible and adaptable approach for providing affordable buildings. The catalogue also affirms the beginnings of standardization for building materials and assemblies.

Industrial and design collaborations – industrializing the kit

As material standardization developed along with theories of dimensional coordination (Bemis 1933), industrial production became the model for a type of industry-sponsored pattern book signifying novel materials and methods. An example promoted by the Douglas Fir Ply-


D. N. SKILLINGS AND D. B. FLINT'S

ILLUSTRATED CATALOGUE

OF

PORTABLE

SECTIONAL BUILDINGS.

PATENTED NOV. 19, 1861.

ADDRESS:

D. N. SKILLINGS, 101 *State Street, Boston,*

AND 108 WALL STREET, NEW YORK,

OR

FLINT & HALL, 6 *Central St., Boston,*

AND 114 WALL ST., NEW YORK.

FIG. 4 DN Skillings and D.B. Flints catalogue cover.
Source: https://archive.org/details/SkillingsFlintCCA196560/page/n21

wood Association (DFPA)[6] illustrated an important paradigm shift in the relationship between industrialisation and architecture. The architect became a marketing tool for promoting the use of a particular material.

All the designs encouraged self-build from a 32 square-foot module (4'x8' sheets) with the use of plywood in envelope, structure, furnishings and interior partitions. Architects were commissioned by the DFPA in a manufacturer's association driven process. Most designs adapted an American modernist aesthetic to a regional and woodland idyllic setting. "The Ranger A-Frame" designed by Nagel and Associates (design no. 15 – **[Fig. 5]** demonstrated the regionalist adaptation of modernist axioms (kit building, material truth, structural expression, modular coordination). The simple A-frame was composed of 2-by-12 beams anchored to a concrete pier foundation. The interior and exterior plywood panels dictated the spans and overall dimensions. The timber A-frame was nothing new. Its simple triangle arch structure is an age-old building system. However the dimensional coordination was a specifically modern tenant. "The Ranger A-Frame", and the DFPA pattern book embody the leisure zeitgeist that accompanied the concept of the kit for post-war living.

The desire for an industrialized house building kit that optimizes construction efficiency, costs and mass-production has spanned eras, customs, cultures and even public policies[7]. The history of architecture and prefabricated construction recounts this sometimes confluent but often divergent tale. The early 20th century economic crises, social turmoil and industrial development shaped icons of prefabricated kits or sub-assembled components for housing. Projects such as "Lustron" in the United States, AIROH "Aircraft Industries Research Organisation on Housing" in Great Britain, government owned and operated precast concrete panel plants in the USSR and Daiwa's "Midget House" in Japan all convey the modernist 20th century fantasy of factory produced housing. Often supported by the transfer of military knowledge and processes to

FIG. 5 Ranger A-Frame designed by Nagel and Associates. Source: Douglas Fir Plywood Association Second Homes For Leisure Living Deers Press Seattle 1960

6. "Douglas Fir Plywood Association Second Homes for Leisure Living" Douglas Fir Plywood Association, 1960. Accessed on June 26, 2019 https://archive.org/details/SecondHomesForLeisureLiving

7. This narrative emerges from extensive literature on the topic and the following references in particular:
Kelly Burnham, *The prefabrication of Houses* (Cambridge : MIT Press, 1951)
Colin Davies, *The Prefabricated House* (London: Reaktion Books, 2005)
Albert G.H. Dietz and Laurence S. Cutler, *Industrialized Building Systems For Housing* (Cambridge: MIT Press, 1971)

civilian industries, many manufactured experiments were also supported by important housing agendas and policies in their respective countries. Media portrayed the kit as a way of facilitating construction and bringing quality production methods learned in parallel industries such as vehicle production to architecture. The problem of industrializing housing construction was the subject of specific literature touting the advantages of packaged intelligent housing systems.[8] Surveys of dwelling systems by Kelley (1951) and later by Meyer-Bohe (1959) speak to the far-reaching influence of prefabrication and the kit house theme in particular.

8. See examples Unknown, "US tackles Housing Shortage" *Life magazine* April 15, 1946: 29. See also Robert Lasch, "What to look for in prefabs." *Popular Science*, August 1946: 66.

Architectural projects and manifestoes spawned by the media's prefabrication rhetoric sustained the founding principles of modernity. From Walter Gropius' and Konrad Wachsmann's "Packaged House" (Herbert 1984), to Jean Prouvé's "House For Better Days" (Hoffman and Hummery 2018), the kit pointed out the architect's capacity to design an object and propose a veritable instruction manual for a modern lifestyle. The architectural kit of parts was the union of architecture and industry which invented a new language for architecture challenging existing models. Since modernity both fields, architecture and industry, have outlined divergent trajectories (Davies 2005). Architecture established an idealized representation of prefabrication while the prefabricated construction industry has largely remained in a mass production paradigm; The kit of parts lent itself to an idiom that identified with intelligent design and an era of technological advancement. Along with the efficiencies of twentieth century Fordisms applied to architecture, the kit was seen as a way of offering an alternative to repetitive prefabrication as it could be customized to fit a specific user's needs. Building a great number of variable plans from a set number of pieces and parts would surely reform architecture's production.

The catalogue and the architectural journal are the two main elements which contributed to the idea of the kit percolating mainstream construction as it would be possible to envision an architecture assembled from off-the-shelf components. Military technology and the ongoing threat of wars pushed for the industrialisation of housing systems as for many it was seen as a way of maintaining military production capacity in the event of war. This transfer of technology along with the fact that many architects had been in military service contributed to the kit being understood as a specifically modern method of construction and symbolized the integration of the architect within industry. The threat of war also contributed to the idea, in the USA, that a house should not only offer protection, but it should be easy to build and mobile. The proposal of the "Nissan Hut" or Buckminster Fuller's "Dymaxion Deployment Unit" as a form of dwelling elucidates the idea that architecture and modern architecture during the post-war years was being influenced by war and its production methods. Further the architectural media became a force to

promote the kit as both medium and message as it portrayed the essential elements of modernity.

A special issue of *Architectural Forum*, September 1942, entitled "The House of 194X" presented this particularly fertile time for American prefabrication. The issue endorsed prefabrication as the most significant development in building techniques. All areas of the construction process were affected and the factory would yield the post-war house. The editors cited the 73 362 prefabricated wartime units produced by their contemporary industry as proof of the sector's proficiency. Applied to every dwelling function, it was the need for adaptability and customization which characterized *Architectural Forum*'s avant-garde take on a need for open systems capable of achieving multiple design options based on component standardization and modularity. Sameness was not an option. If prefab was to succeed it "*must be able to adapt to different needs resulting from changes in family composition as a family grows «older»*". [9]

9. Editors, "The House of 194x," *Architectural Forum.* September 1942: 32.

Architectural Forum would continue to showcase industrialized building systems in the years that followed promoting prefabrication as effective for saving costs and time. Steel component based systems demonstrated the magazine's open systems approach as components could be assembled to organize any design.

The "Light Steel Bethlehem System"[10] composed of trussed joists and wall studs typified variable prefab as both wall and floor components could be mass-produced but deployed in multiple variations.

10. Part of a six-part series on the theme of the "Prefabricated House", the March 1943 issue of *Architectural Forum* presented a series of steel kits.

2.0 The architectural kit of parts as medium and as message

"What is a house ?" authored in July 1944 in *Arts and Architecture* by Charles and Ray Eames (1944) famously represented **[Fig.6]** the problem that would fascinate and obsess architects for a time to come. It would respond to user's needs and would necessarily be informed by technology. While not precisely positing the case for a kit of parts architecture, their position was certainly clarified by their 1949 prototype, "Case Study House 8", one America's important architectural experiments. The problem of the post-war house was being addressed not only in architectural circles but in industrial and political circles as well and prefabrication was the way of the future. The kit of parts within architectural literature became synonymous with innovation and the capacity to house returning veterans. "Lustron" is the iconic, successful, failure in terms of prefabricated steel kit housing pushed by both industry and the political system. It can also be argued that villages such as Roger Young Village in Los Angels, which employed a domesticated version of the "Quonset Hut" exposed a military outlook on housing (Cuff 2000). The meeting of architecture with production and industrialisation was a recurring theme in modern architecture purported by many authors, this paper explores the robust narrative that

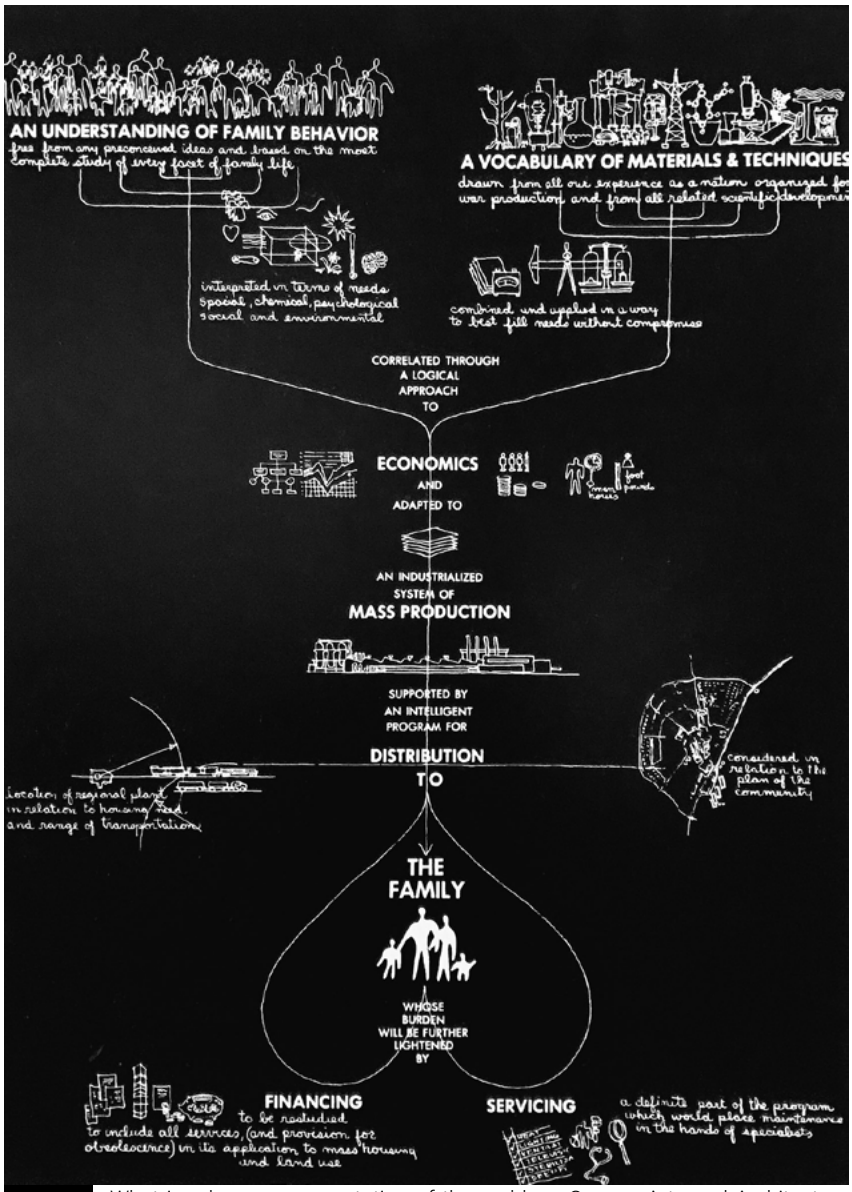


FIG. 6 What is a house representation of the problem. Source: Arts and Architecture July 1944

emerges from the study of three diverse productions all stemming from the kit ideal proposed as a model for reforming housing and eventually for city planning.

Arts and Architecture - architecture with an optimistic message

The immigration of influential members of the European avant-garde to the United States transported and secured modernist values in American architectural academia in the 20th century. The combination of European modernism, its attraction to the American building culture of light industrialized components (balloon frame and skeletal steel) and the American pioneer spirit contributed to elevating prefabrication to a type of intended goal for architectural solutions. While present throughout the United States, California was a particularly fertile context for this type of modernism. Already in 1921, Rudolf Shindlers' "Kings Road House"

employed a project specific kit with its on-site cast tilt-slab concrete construction. Considered by many as the first truly modern house in the USA, its Japanese inspired details also explore a type of timber kit.

Using a media outlet to propose what was new in architecture is not specific to California, however the scale and ambition of "The Case Study House Program" proposed as a veritable production of housing ideas for post-war America (Goldstein 1990) determines its value in influencing what has become known as mid-century modern. The January 1945 issue of *Arts and Architecture*[11], formerly California Arts and Architecture was a call to action for architects to explore "*good design potentials*"[12] through a series of prototype houses which would be followed, studied and advocated by the magazine in order to shape some "*creative thinking by good architects and good manufactures*"[13]. The post-war house was to be a commodity. Implemented by Arts and Architecture magazine and championed by its editor John Entenza, "The Case Study House Program" was based on values of innovation, scalability, reproducibility, affordability and personalization. 13 out of the 36 residential prototypes were built on the conviction that architecture could be both mass-produced and fitted to owners' personalities. In 1949, fed by European avant-garde influences, the transfer of knowledge acquired in military service and his work with the magazine, Charles Eames, designed what would come to be known in architecture as perhaps the most famous kit house. The Eames' proposed the "Case Study House 8" and collaborated on the "Case Study House 9". Eames explored an open frame structure, a clear span space, structured by a steel skeleton leaving considerable flexibility to potential occupants and users. This variability was based on the assembly of ready-made industrialized and off-the-shelf components akin to what the Eames' had developed for their infamous children's "Toy" (Colomina, Brennan, and Kim, 2004).

11. John Entenza, "The program," *Arts and Architecture*, January 1945: 37.
12. Entenza, "The Program," 37.

13. Entenza, "The Program," 37.

Regularly linked to Charles and Ray Eames' "Case study house 8" and "The Case Study House Program", the kit culture has a deeper-rooted tradition in California. The mid nineteenth century brought over 300 000 forty-niners and varied transportable housing from United States, Latin America, Britain, and Asia, diversifying California's social make-up and contributing the progressive nature of its building culture.

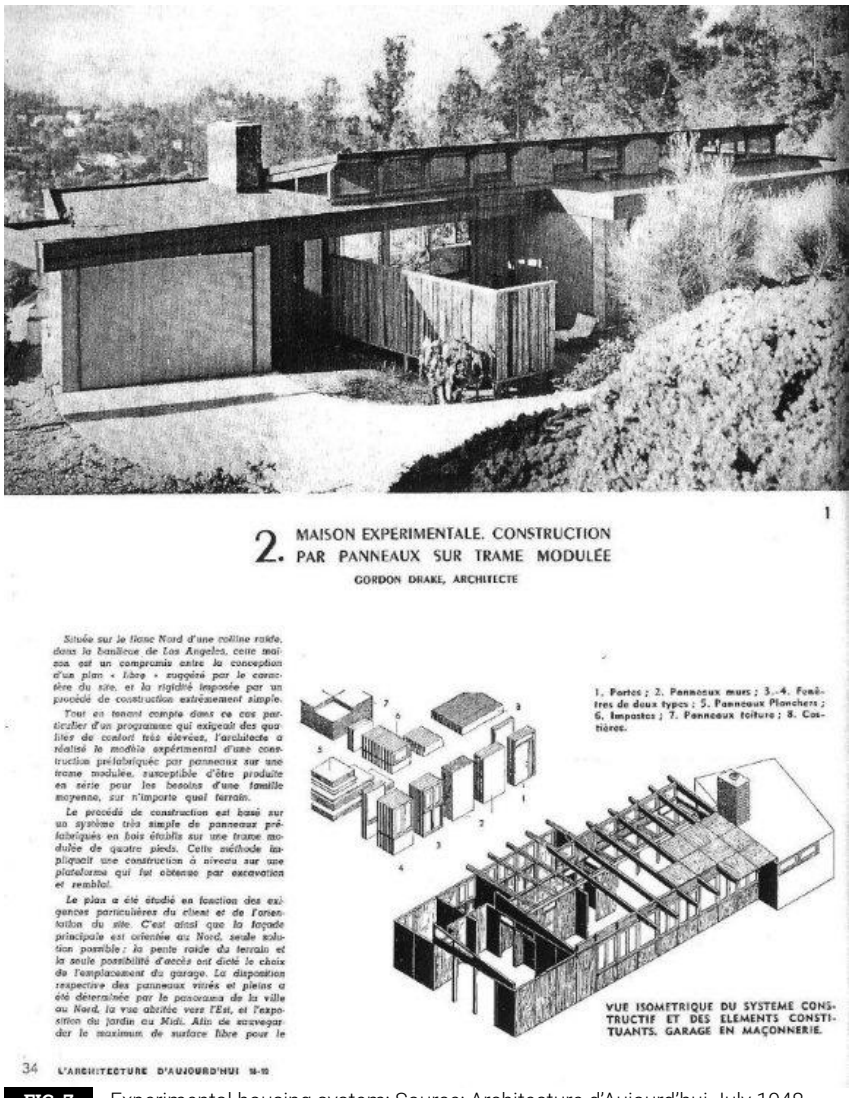
This tradition of a progressive building culture exemplified by the designs of Bernard Maybeck, and the influence of pure modernists like Walter Gropius and Richard Neutra combined to create an American / California modernism based on crafting architecture rather than a pure separation of craftsmanship from industry. *Arts and Architecture*'s "Case Study House Program" is a prime example of the era's and the setting's progressive ideas for housing. The CSHP designs revealed the common themes of horizontal space, centrally clustered flexible spatial composition and modular coordination of components.

An example of the program's and the California kit influence was printed in *Architecture d'Aujourd'hui* in july 1948[14] **[Fig. 7]**. Gordon Drake an architect who died tragically in his early thirties had a brief but prolific career inspired by California modernism. Drake designed a series of houses based on a four-foot grid module. The experimental house system proposed interchangeable components based on a three dimensional grid. The strategy was concurrent to the Modular Standards Association and the American Standards Association proposals for a 4-inch cube module that was to facilitate building from a point of view of systems and component integration. Gordan Drake's proposal for his experimental houses was based on modular coordination composed of floor, wall and roof panels, stressed skins attached to a simple open frame structure.

14. See experimental kit house of prefabricated components by Gordon Drake in *Architecture d'Aujourd'hui* July 1948

Another influence beyond modular coordination of the case study house program was the crossbreeding of "*good architects*" and "*good manufacturers*"[15]. Crossing industrial knowledge with architecture was an underlying theme of modernism. As the post WW2 era set off a baby boom brought on by both economic expansion and a renewed optimism of peace time, the modern house and its definition was the topic of

15. Entenza, "The Program," 37.



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2. MAISON EXPERIMENTALE. CONSTRUCTION PAR PANNEAUX SUR TRAME MODULÉE

GORDON DRAKE, ARCHITECTE

Située sur le flanc Nord d'une colline raide, dans la banlieue de Los Angeles, cette maison est un compromis entre la conception d'un plan « libre » suggéré par le caractère du site, et la rigidité imposée par un procédé de construction extrêmement simple.

Tout en tenant compte dans ce cas particulier d'un programme qui exigeait des qualités de confort très élevées, l'architecte a réalisé le modèle expérimental d'une construction préfabriquée par panneaux sur une trame modulée, susceptible d'être produite en série pour les besoins d'une famille moyenne, sur n'importe quel terrain.

Le procédé de construction est basé sur un système très simple de panneaux préfabriqués en bois établis sur une trame modulée de quatre pieds. Cette méthode implique une construction à niveau sur une plateforme qui fut obtenue par excavation et remblai.

Le plan a été étudié en fonction des exigences particulières du client et de l'orientation du site. C'est ainsi que la façade principale est orientée au Nord, seule solution possible : la pente raide du terrain et la seule possibilité d'accès ont dicté le choix de l'emplacement du garage. La disposition respective des panneaux vitrés et pleins a été déterminée par le panorama de la ville au Nord, la vue abritée vers l'Est, et l'exposition du jardin au Midi. Afin de sauvegarder le maximum de surface libre pour le

1. Portes ; 2. Panneaux murs ; 3.-4. Fenêtres de deux types ; 5. Panneaux Planchers ; 6. Impostes ; 7. Panneaux toiture ; 8. Cheminées.

VUE ISOMETRIQUE DU SYSTEME CONSTRUCTIF ET DES ELEMENTS CONSTITUANTS. GARAGE EN MAÇONNERIE.

34 L'ARCHITECTURE D'AUJOURD'HUI 18-19

FIG. 7 Experimental housing system: Source: Architecture d'Aujourd'hui July 1948

many architectural machinations. Architects had been employed in the war effort and the material knowledge they gained was being deployed toward civilian use. Charles and Ray Eames' office was notably active in bringing modern materials such as plywood and plastics from military explorations in leg and arm splints to daily use in furniture or for housing.

The Kwikset Lock Company mandated a lesser-known work by the Eames' office. Both interested in housing and producing prototypes architects and industrialists sought to serve and supply the masses. Founded by Adolf Schoepe and Karl Rhinehart in 1946, the Kwikset Lock Company was founded on their patent for a quickly installed tubular door lock. In 1948 the company set up as factory in Anaheim and became familiar with the Eames' and their work through common acquaintances. "The Kwikset House"[16] prototype designed in 1951 was never built but was proposed as a self-build affordable timber kit [Fig. 8]. The Kwikset Lock Company intended to market and sell the kit to include their hardware. The simple kit was composed of a vertical post and curved beam timber structure which outlined a flexible and adaptable interior space. The one-inch scale model showcased the Eames' furniture and their signature modular organisations applicable from toys to buildings and cities (Zinguer 2004).

Arts and Architecture, the Eames', and other optimistic young architects shaped and inspired by European avant-garde, elevated the kit of parts to a generation's propagandist tool for promoting a new language for architecture: manufactured, customizable and replicable. If the kit of parts promoted progressive minded ideas on architecture and its industrialization, it remained fairly marginal in shaping the ordinary post-war house. It did however shape how modern architecture was envisioned and how it is published. To this day magazines like *Dwell* celebrate "The Case Study House Program" as a symbol of an optimistic modernity in America. [17]

16. "The Kwikset House," Eames Office, accessed on June 26, 2019 https://www.eamesoffice.com/the-work/the-kwikset-house/

17. Jennifer Baum Lagdameo, "A look at 10 iconic case study houses," accessed June 26, 2019 https://www.dwell.com/article/a-look-at-10-iconic-case-study-houses-in-california-abb9ca3c

"The Standard of Living Package": architecture as a tool for survival

The underlying tones of military influence, decentralization of the city and the increasingly mobile lifestyle would remain an influencing power. *Arts and Architecture* would continue to explore the post-war house until

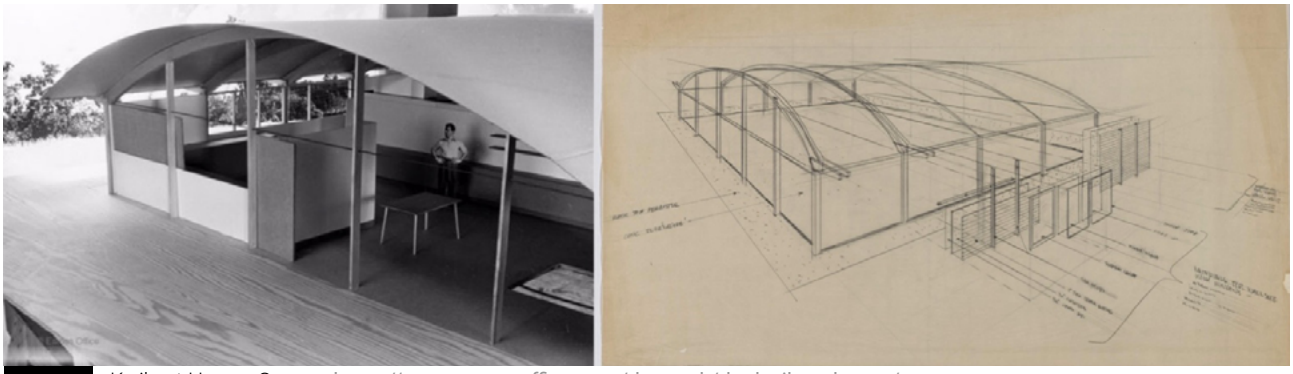

FIG. 8 Kwikset House: Source: https://www.eamesoffice.com/the-work/the-kwikset-house/

1962. The off-the-shelf kit in architecture that would lead to the industrialization of the house, proposing an efficient and low-cost "*machine for living*" would not come to fruition at least not in massive terms. However, the kit as both an elucidation of military undercurrents and a solution for the housing shortages would inspire and become a message for potential mobility during the cold war years.

Well known for his Dymaxion inventions Richard Buckminster Fuller's designs are abundantly documented. From his work on the industrialized service/bathroom core patented in 1913 to the USA pavilion at Expo 67 in Montreal, Canada to his many Dymaxion experiments illustrate the proficiency with which Fuller's ideals sought to reform construction through an ideal for scientific efficiency. Even today, the Buckminster Fuller Institute continues to promote Fuller's ideas and lays witness to Fuller's capacity to federate industry, engineering and academia (Pang 1996). During the late 1940s and early 1950s "The Fuller Research Foundation" (FRF) based in Forest Hills, New York, instigated many experiments linked either directly by military requirements or by the indirect pursuit of building systems, which could be deployed both easily and economically. Overseen by Fuller, the FRF used architectural education, workshops and publications to describe their visions of one of the most iconic building kits of the twentieth century: the geodesic dome.

Filed on December 12, 1951, Buckminster Fuller's patent, "Building Construction",[18] describes a system for enclosing space with a minimal amount of materials through the geometric principles of great circles. The patent defines geodesic construction through three interrelated principles: the stability of triangles, the geometry of a spherical icosahedron, and truss principles to increase the moment of inertia of a dome's shell without substantially increasing its weight.

18. R. Buckminster Fuller "United States Patent no. 2682235 - Building Construction" June 29, 1954; http://www.google.ca/patents/US2682235 accessed July 1, 2017

Reducing weight, an obsession Fuller acquired from his military work, is important in any structure but is particularly important in large spanning structures that are free of any interior obstructions. Triangulated structures or trusses are systems that systematize geometric patterns of consistent components to transfer loads and stresses. An interrelated curved network of triangles, Buckminster Fuller's "Geodesic Domes" epitomize using geometry as an architectural device; the 20-faced icosahedron in particular, to produce a large variety of geodesic dome kits for buildings of any scope and size. The icosahedron's composing equilateral triangular faces' vertices are extended outwardly to approximate a sphere and their joining segments materialized to form a hemispherical dome. The resulting latticework of constructed triangles relies on variable length segments and geometrically agile connectors. The domes were proposed as a revolution in building and as a tool for mobility as the domes could be built from lightweight materials, assembled, disassembled and reassembled in any context. The dome would not only cover architectural space

but eventually mediate it from inclement weather and predators. The dome would be a formidable kit for decentralizing housing in America.[19]

Geodesic principles were explored in a large series of dwelling kits from Fuller's own home to experiments undertaken as part of FRF (Gough 2009, Wong 1999) – the home was no longer viewed as a perennial context based social construction but a product of industrial development to be moved and replaced as needed in the event of a catastrophe.

> *"In the spring of 1949 a course by architect Buckminster Fuller presented students at the Institute of Design in Chicago with the problem, as apocalypse-cum-homework assignment: "The city is to be evacuated. All residential and industrial concentrations of 50,000 persons or more are in immediate danger of annihilation. Consumable goods now directed towards these areas will be diverted to smaller decentralised communities. Seven days are allowed in which to gather all living mechanics necessary to maintain a high standard of living for a family of six – two adults, two children, two guests. Everything not decentralised will be destroyed."* [20]

Along with the dome, The "Standard of Living Package" was Fuller's response to the need for industrializing a low-cost house that could be moved or easily replaced. The articles in *Perspecta* and *Life*[21] confirm Fuller's principles in both architectural journals and mass media showcasing the industrialized house with the utility package to serve basic needs. If Gottfried Semper's analysis of the "Carribean Hut" (1851) defined an inclusive vernacular architectural language in modernity, Fuller's kit submits the required commodities to replace Semper's ceramic hearth. In this commodified hearth, housing strategy, building techniques, and military technologies fuse together to produce an ambitious dwelling kit for the masses.

Buckminster Fuller's work with the group of students[22] used the cold-war setting as his housing designs and geodesic structural prototypes performed an architecture of protection and survival. His "Standard of Living Package" proposed a potential industrialized process to reduce costs and make a better house. This included securing financing, material procurement and marketing. Fuller's kits became a type of architectural propaganda using academia, the architectural studio and workshop setting to push his agenda for change.

The proposed kit was a transportable container that would unfold into a service core **[Fig. 9]**. The container's sides would simply fold out to become the dwelling unit's floors and out would come all the modern conveniences and commodities that a family of six would need to live comfortably in a decentralized location. The geodesic dome structure covered in plastics would shelter the unit. The two-component kit, a

19. R. Buckminster Fuller, "The Autonomous Dwelling Facility," *Perspecta* vol. 1 (Summer 1952): 28-37.

20. Fuller, "The Autonomous Dwelling Facility," 28-37.

21. See description of Fuller's Wichita House in *Life* April 1 1946.

22. Fuller, "The Autonomous Dwelling Facility," 28-37.

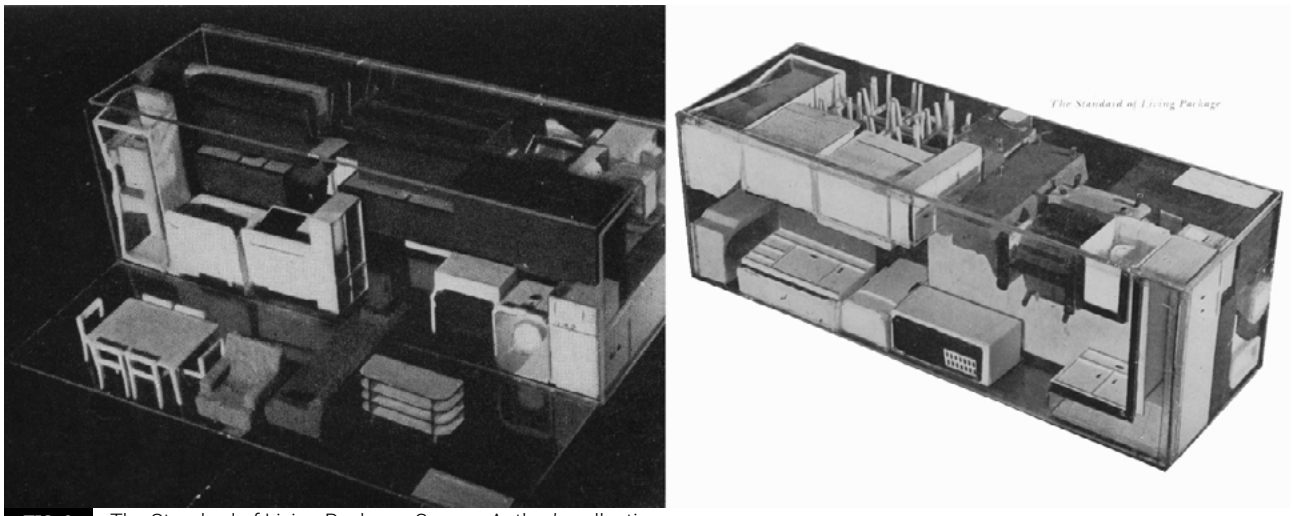

FIG. 9 The Standard of Living Package. Source: Author's collection

transportable container and a geodesic dome, would allow one to conceivably set-up house anywhere.

Fuller's Fuller Research Foundation was modelled as a design office but also as a branch of military engagement. The "Autonomous Dwelling Unit", the "Geodesic Domes" and even the earlier "Wichita House" branded architecture with the aesthetics, efficiency and material knowledge gained from military training. The kit of parts based on the repetitive use of mass-produced components allowed for building large spanning structures with similar and replaceable parts. Each deployed unit was the modular unit of an overall building system. The easy kit rhetoric percolated every part of the Fuller Zeitgeist.

Plastic shells as territorial kits - architecture for the mobile man

The kit of parts as a conceptual product of the post-war era elevated components that were cheap, quick to produce, replicable and easily replaced. As many kits developed concurrently to the development of new materials, plastics became representative of post war commodification of architecture and were ideally suited to the idea of a lightweight kit not specific to any context.

Plastics presented the flexibility of reinforced concrete without the weight limitations. Plastics' flexibility was emblematic of modern society's main constituent: the need for constant change. Social paradigms were being challenged at an alarming rate. Research in architecture and building technology paralleled this social development, as systems' flexibility became a focal point for exploration. Plastics in construction were everywhere and in mass media in particular portrayed as the future of building. *House and Home* even presented a timeline for their streamlined use in all building systems.[23] Without a history before industrialisation, plastics and polymers more precisely were an experiment in material

23. Unknown, "Timetable for the Use of Plastics in Construction," *House and Home* (September 1956): 122

chemistry and their production was based on the efficiencies developed in the laboratory and in wartime use.

Hardening resins, such as Bakelite invented by Leo Hendrik Baekeland in 1907, were developed in building materials from panels to laminates. The monocoque and stressed skin structures developed for military use in aluminum and in reinforced plastics certainly revolutionized modern building culture as they permeated post-war building. The stressed skin and the monocoque combine structure and envelope to produce an optimal weight to strength ratio. Shells could be purposed toward building, as they were strong, light and potentially relayed wartime industries toward civilian use.

The glass-fibre reinforced plastic (GRP) shell panel was symbolic of new uses for composites in architecture. Used notably as the intrados and extrados film over an expanded polyurethane core, the monocoque shaped in variable compositions, juxtaposed on simple grids was neither skeletal nor massive and proposed a new formal language.

Arthur Quarmby[24], a particular strong proponent of this use of plastics in architecture explored a modular system of GRP monocoques for British Railways' relay stations, a similar system for Bakelite ltd and for use in temporary housing. Quarmby's approach was based on identical shells (combining walls and roofs) for corner units and wall segments. The system was expandable. A base square unit could be deployed to a limitless length in one direction with only two reusable moulds.

In the 1950s, Marvin E Goody and Frank J Hager from the Massachusetts Institute of Technology also explored glass reinforced plastics for buildings. The MIT researchers united with industries such as Owens Corning to study new potentials for plastics in architecture. Their work led to an association with Monsanto on the "All Plastic House of the Future", exhibited by Disney in Anaheim, California from 1957 to 1967 and to a lesser-known project for a flexible school structure. Promoted as the future of housing the Monsanto house illustrated the potential use of plastics in every building system.[25] The kit was no longer just a tool for showcasing construction simplicity, it helped commodify architectural production and became a message for the future of building **[Fig. 10]**. The message was that architects were not only responsible for building but equally a tool for its publication and for defining a new lifestyle. Houses by Goody and Hager, Alice and Peter Smithson and also by Shein and Magnant portrayed the future of living in plastics as a global phenomenon (Vergnot-Kriegel 2011).

The monocoque shell skins for the Monsanto house helped develop an ideal form-resistant structural shape. The monocoque shells could be moulded into virtually any profile and nested to be easily transported to any site. In the case of their experimental elementary school, Goody and

24. See a number of Quarmby's proposals at http://www.frac-centre.fr/_en/art-and-architecture-collection/rub/rubauthors-316.html?authID=156 accessed June 26 2019.

25. Unknown, "Plastics and Houses," *House and Home* (September 1956): 134

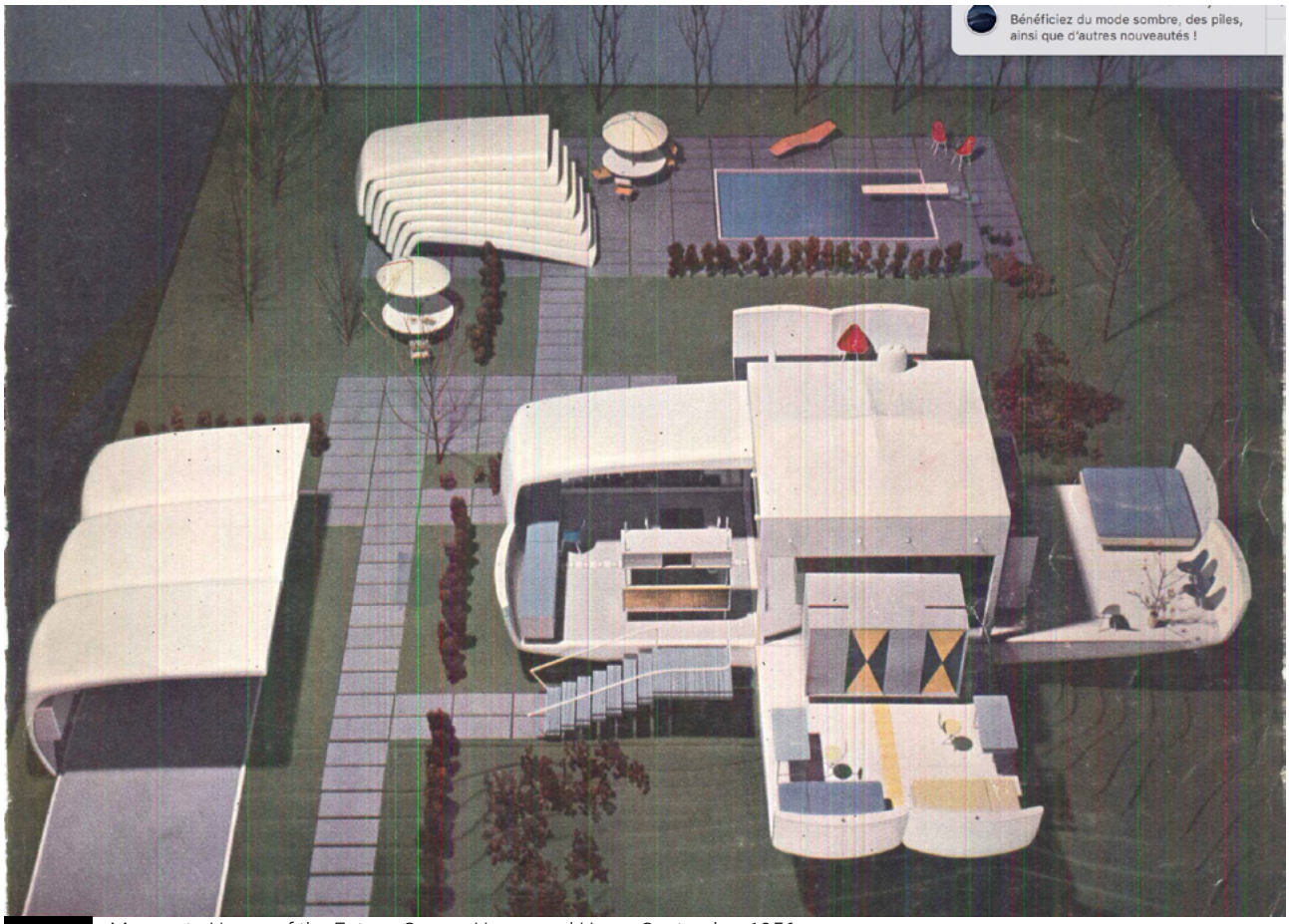

FIG. 10 Monsanto House of the Future: Source House and Home September 1956

Frank developed a hyperbolic paraboloid (a curved surface shaped like a horse saddle) skin composed of a foam insulated core (25 mm) moulded between two thin fiberglass reinforced (1.5 mm) skins. Simple to produce, these shapes and objects became the source of combinable and coordinated architectural components. Many such projects developed concurrently for different scales and different settings. The "DO-bausystem" in Germany, the "Tetrodon" in France, Guy Gérin Lajoie's modular plastic panels for the Arctic in Canada and both "The Ventura" and "Futuro" houses by Matti Suuronen in Finland all employed similar systems casting fiberglass reinforced plastic components for producing building system kits. Units or panels could simply be snapped or bolted together streamlining construction [Fig. 11].[26]

George Candilis proposed "Hexacube"[27] in the early 1970s employing matching and stackable fiberglass reinforced shells to form dwellings. The cube facilitated clustering while hexagons were used to match cube faces together. The basic unit was a moulded half cube [Fig. 12], which could be employed as the upper or lower part of the cube. Each 5m^3 cube was moulded with half-hexagonal shaped openings, which formed full hexagons when the half cubes were matched. The hexagon opening acted as the "Hexacube's" reproductive organ; their alignment and subsequent affixing made it possible to achieve multiple arrangements. The openings

26. Author, "Prefabrication experiments - 177 - Geometries - 08 - Hexacube and plastics in architecture" Accessed on November 6, 2019, http://prefabricate.blogspot.com/2018/10/prefabrication-experiments-177.html.

27. "Prefabrication experiments - 177 - Geometries - 08 - Hexacube and plastics in architecture"

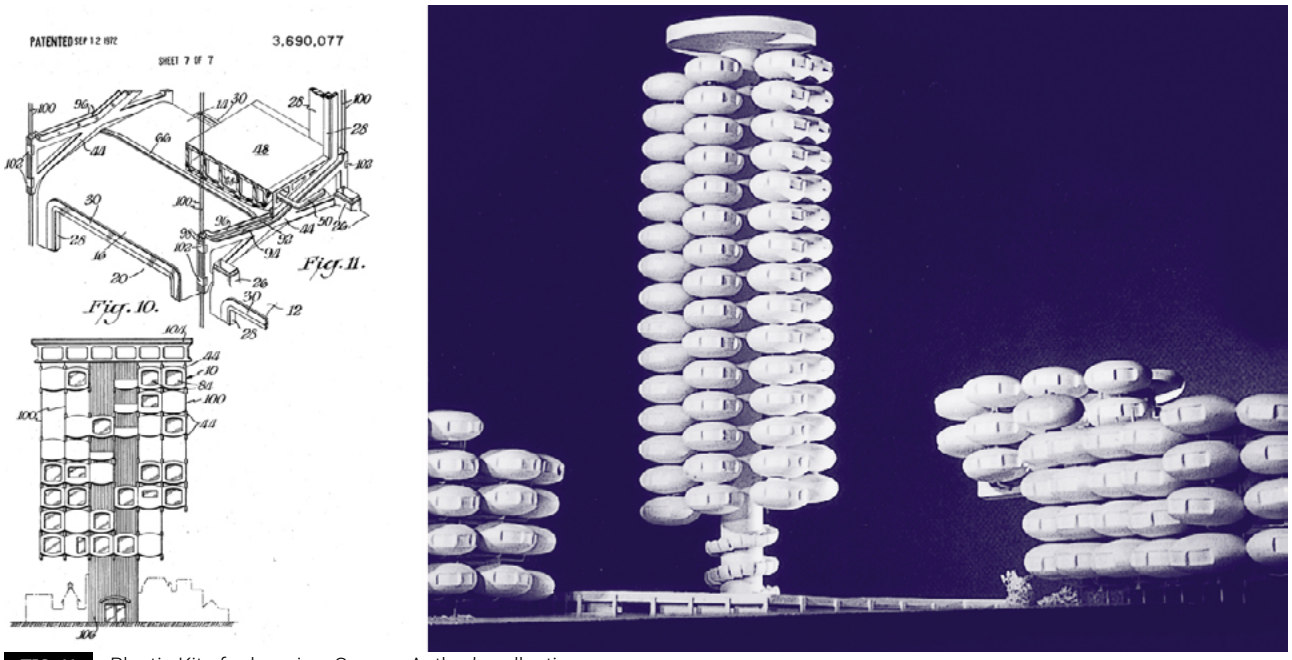

FIG. 11 Plastic Kits for housing: Source: Author's collection

could be adapted with a series of facades or functional hexagonal shaped units, varying function and appearance. A series of accessories, rectangular prisms half the size of the cube programmed by function, hygiene, storage, kitchen or other services, could be plugged into the basic unit creating an infinite number of patterns and uses. Each half cube could be piled for efficient delivery, eight deep, as one would stack plastic utility chairs. The cube's edges were tapered and chamfered to facilitate casting and recasting using the same moulds.

Dubigeon Plastics produced Candilis and Anja Blomstedt's "Hexacube" in 1972. Although only a marginal number of units were produced, the system showcased a manner in which knowledge transfer from the plastics industry to architecture made it possible to fabricate objects, architecture, and even cities with similar processes.

These plastic shell kits underscored the development of an imminent hypermobile architecture of transposable pod clusters and aggregations. As polymer chemistry progressed these types of product oriented building systems became more prevalent. Glass reinforced plastic was the main material constituent of the pod aesthetic. Socially, demographic shifts, new modes of transportation and the space race supported the representation of agile, adaptable and flexible future urban systems. The capsule epitomized a future where the social fabric commanded an interchangeable architecture. Patented systems[28] by Kisner or Casoni and Casoni's circular "Rondo" housing pods (Vogler 2015) presented the plastic pods as components in towering megastructure kits, each pod completely eliminating any individualization, as each capsule was identical to its neighbour's.

28. John D. Dalgliesh and Clinton E. Kisner "United States Patent no. US3690077A - Building Construction" June 29, 1954.

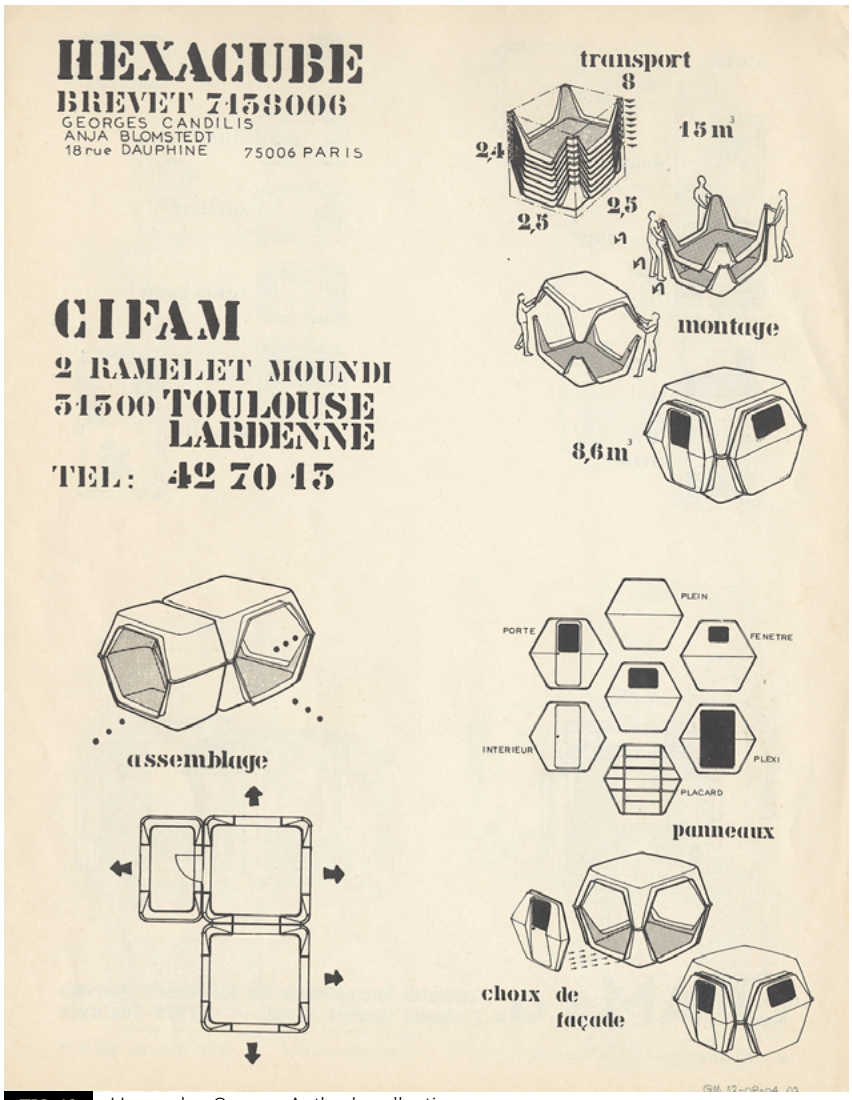

FIG. 12 Hexacube. Source: Author's collection

The kit progressed from a vision of an industrialized house to the image of a cell-based industrialized city. The steel skeleton was replaced by a towering infrastructure into which integrated components could be plugged and unplugged.

3.0 Discussion and conclusion

Designed for assembly, the kit of parts predates modernity in architecture and related more to craft than industry as cutting parts to make them fit together requires a high level of shared knowledge about tools and materials. Industrialization put the power of this knowledge in the factory and assembly by bolts or nails democratized construction. Through this dissemination throughout architectural media the ideal of modular coordination made it possible to reach a type of kit construction for the production of dwellings but also for the production of newness in architecture.

"The Case Study House Program", "The Standard of Living Package" and plastic shell construction while not specifically linked together, certainly trace of vector which proposed the kit as a basis for a new architecture and as a tool for lowering costs, living better, and enjoying the flexibility and mobility of the modern house. As its potential for reforming architecture and everyday construction became marginalized, the kit rhetoric infiltrated architectural media, education and design methodologies. It no longer was seen as a uniquely efficient system to be assembled for the masses to mitigate the post-war housing shortages but could be a way of systemically reforming architecture's production at every scale.

One of the most convincing attempts at defining agile building kits at every scale through modularity was proposed by Swiss designer Fritz Haller.[29] Well known for his association with manufacturer USM for a line of modular furniture, Haller applied his modernist education to develop a scalable construction system applicable to three building types in the 1960s. The "Mini" for houses and residential lightweight construction, the "Midi" for intermediate commercial grade construction and a long spanning "Maxi" version of the component-based system for large structures and a more theoretical systems for urbanism. The skeletal steel systems employed a similar approach. Prefabricated elements for columns, girders, main beams and panels based on a modular 60cm / 120 cm grid normalized construction details and simplified coordination while permitting multiple and adaptable functional and spatial patterns. Haller also applied this integrated vision to city structures **[Fig. 13]** idealizing as Konrad Wachsmann and Charles Eames did in the USA a type of light-

29. Adam Hubertus "Fritz Haller: Systems and Prefabrication" *Detail journal*, (April 2015) : 292.

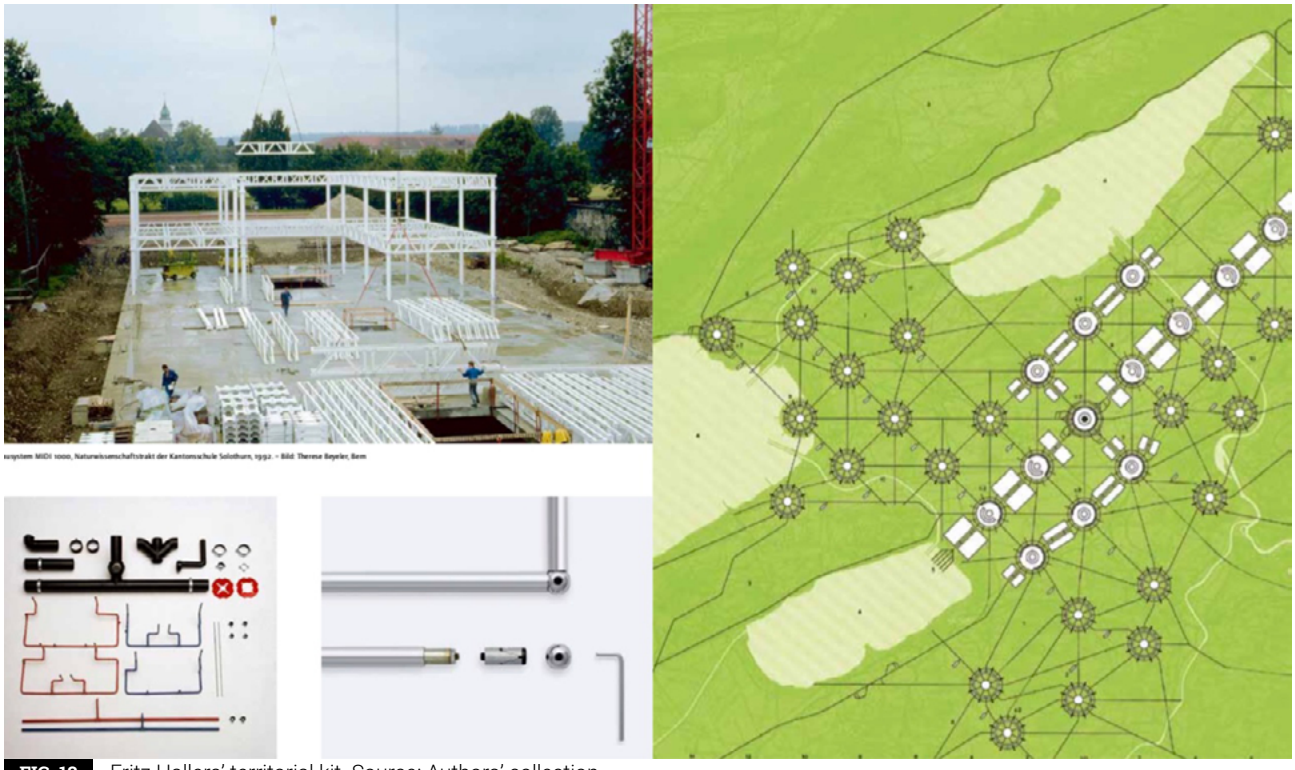

FIG. 13 Fritz Hallers' territorial kit. Source: Authors' collection

weight structuralism adapted to any use. Haller's systems expresse the architectural media's influencing power internationally, elevating the kit as a tool for building at every scale and in any context.

The kit of parts is not just an object in architecture but a mediatic instrument, indicative of the interaction between architectural, construction, industrial and military 20th century histories. The Industrialization of architecture and construction remain elusive to this day as construction methods are mostly conservative, the architecturally designed kit however endures as a type of architectural propaganda. Within the do-it-yourself, hacker and open-source ideologies, the modular, flexible, adaptable, kit-of-parts has become the reflection of a new type of architectural adaptability, "The Wikihouse"[30] project presented by Alistair Parvin allows for anyone to download, share, cut their own version of the kit. A heuristically share knowledge gained from the crowd, reforms building culture form an industrially produced kit to a type of crowd sourced, amended, enriched and perfected kit. Digitilization of construction has brought production back into the hands of the many returning the kit to its conceptual roots: a social product and production for the globalized construction of housing.

30. "About Wikihouse," Wikihouse, accessed on June 26, 2019, https://www.wikihouse.cc/About