PLASTIC: MHOF

(Monsanto House of the Future)

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GRAHAM FOUNDATION GRANT APPLICATION

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On October 28, 1952, architects from around the nation gathered for a two-day conference held in Washington on plastics in building to "dream boldly about the future."[1] As reported by Betty Pepis, participants declared that there will be "a Golden Age of American architecture" when and if architects learn "to take full advantage of new plastic materials" advanced during World War II.[2] Architects purported that through the use of new lightweight plastics, "upkeep and maintenance" and "dark corners" could be virtually eliminated in housing. One architect presented the ideal vision of a house that could completely fold up and out of the way through the use of mobile plastic partitions. Another even suggested the construction of "plastic cities" built over tropical waters through the advent of high-strength waterproof plastics. Robert K. Mueller, vice-president of the Plastics Division of Monsanto Chemical Company, concluded the conference by claiming, "the future of plastics in building is limited only by our imaginations and the public acceptance of new concepts in living."[3]

During the 1950s, designer imaginations were brewing with possibilities for postwar construction in plastics; however, as Monsanto realized, if there was ever going to be any future to these fantasies, it was not going to happen without public interest and approval. To achieve this goal, on October 5, 1955, Monsanto executives authorized the proposal for their House of the Future project, as initiated by manager Ralph F. Hansen of Monsanto Plastics' Marketing Division. The Monsanto House of the Future (referred to by its creators as MHOF) was designed to enhance and guarantee the long-term viability of the company's new wartime plastics manufacturing industry. To ensure peacetime applications of their products, Monsanto promoted both the need and the desire for a new paradigm of modern architecture practice—"plasticity."

Wartime Production

As reported in 1951 by Frank Curtis, director of Monsanto's long-range development program, the smooth transition made between peacetime and wartime applications of the company's chemical manufacturing lines was considered a model of success. Prior to World War II, the chemical industry rapidly expanded

1. Betty Pepis, "Plastics Limned in 'Dream Houses,'" *The New York Times*, 29 October 1952.
2. Ibid.

production of basic manufactures that could be easily converted to wartime uses "merely by changing the destination of a tank car."[4] Both the chemical industry and the Chemical Warfare Service were aware that certain kinds of ammunition and high explosives would be in great demand during a future war, and companies such as Monsanto focused the peacetime efforts of their chemical divisions on manufacturing domestic products that had base materials similar to those of explosives.[5] With domestic sales of their antiseptics, detergents, and cleaners setting all-time records in 1939 and 1940, Monsanto was able to swiftly redirect its expanded peacetime production of the base materials phosphorus, sulfuric acid, chlorine, trisodium phosphate, caustic soda, and phenol to the production of various explosive materials in order to meet peak World War II demand.[6]

Unlike the chemical industry, the plastics industry was not prepared for an easy transition from domestic to wartime production. A company report on Monsanto's World War II efforts acknowledged that "while conversion to war in the old organic-chemical line was by and large not too difficult, the Plastics Division had an extremely difficult time."[7] Plastics had not been developed during peacetime with wartime applications in mind. Frustrating Monsanto's efforts to support the war was the fact that the defense industry was unfamiliar with the potential uses of synthetic chemicals developed and used domestically. When World War II broke out, Monsanto's major products consisted of safety-glass plastic, Resinox molding compounds (used to make plywood), Cellulose nitrate sheets and rods, phenolic resins (used in juke boxes), and polystyrene (formed into novelties and gadgets).[8] As remarked by Curtis, "Practically none of [these product's] uses were approved for wartime."[9]

With traditional materials such as metals predicted to fall quickly into short supply during the war, the demand for plastics could prove dramatic. R. D. Dunlop, operating chemist of Monsanto, observed,

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3. Robert Mueller, quoted in ibid.
4. Frank Curtis, "Monsanto in World War II—Summary of Division and Plant Reports Written in 1945," 15 April 1951, 1, Monsanto Company History World War II, box 4, series 10, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.
5. Ibid.
6. Ibid.
7. Ibid., 14. See also "Development Projects which were Either Completed by or Received the Attention of Monsanto during the War," Monsanto Company History World War II, box 4, series 10, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.
8. Curtis, "Monsanto in World War II," 15 April 1951, 15, Monsanto Historic Archive Collection.
9. Ibid.

"the first reaction after Pearl Harbor was that plastics would jump into their own."[10] A problem arose, however, with the replacement of traditional materials by plastic. Dunlop noted,

> When we saw the requirements that [plastics] must fill, it also became apparent that the job was not easy and a lot of hard work was required. The aircraft industry very quickly and emphatically told the plastics industry that plastics in aircraft for structural purposes were a possibility but that no one knew enough about them to safely design an airplane incorporating them. The electronic industry said that some of our materials, particularly polystyrene, had very admirable properties, in some respects, but they were not quite sufficient to fill every requirement....No one in the plastics industry had worried a great deal about specifications.[11]

Unfortunately for the plastic industries, there had been little effort during peacetime to develop materials and methods that could meet the high standards of wartime production. Plastics developed by Monsanto had not been designed for their structural integrity: polystyrene, which had excellent electrical properties that could be utilized with radar, softened at a low temperature; nitrate, which could be used for aircraft glazing, burned too readily and was easily affected by the heat of the sun; Resinox, designed as a general purpose wood resin, was suitable for low-impact applications only; and one of Monsanto's most significant peacetime products, Buvtar, used in safety glass plastics for automobiles, was considered relatively useless for wartime production.

Between 1941 and 1943 Monsanto worked quickly to develop plastics better suited to war. They did considerable work to determine the "physical-mechanical" properties of plastics, so that they could provide data to the Armed Forces and various other manufactures of war materials.[12] They worked to create more viable plastic products and, as needed, built extensive new production facilities.[13] Of great success was Monsanto's development—in cooperation with Owens Corning Fiberglas—of Thalid resin for bonding glass cloth. The brand name product—Fiberglas—was used extensively for light, non-shattering,

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10. Ibid.

11. As an exception to the rule, Dunlap observed that "there was a group in the A.S.T.M. [American Society of Testing Materials] that had seen that some day definite specifications and test methods to supplement these specifications would be necessary." He also noted, however, that "this group worked diligently without great encouragement." R. D. Dunlop, quoted in ibid.

12. Edgar Queeny et al., "Monsanto Chemical Company's Part in the War Effort: Report to George D. Hansen," Price Adjustment Section, Chemical Warfare Service, Washington, 5 February 1943, 5, Monsanto Company History WWII, box 4, series 10, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.

13. Monsanto manufactured Polyvinyl Buvtar for raincoats, gas-protective clothing, hospital sheeting, and military packaging; melamine resins of high resistance for aircraft ignition parts that were exceptional for replacing aluminum in dishware; Resinox with high impact strength for gunstocks, motor shell fuses and mines, tank periscopes, and bomb nosepieces; and Styrene with non-flammable heat-resistant properties for the synthetic rubber program. Queeny et al., "Monsanto Chemical Company's Part," 3–6.

flexible Doron plastic armor suits, and Thalid resin and glass cloth were used in structural aircraft parts such as radomes. [Fig. 1] [14]

During the war, new plastics significantly advanced developments in radar technology, and radomes made almost exclusive use of the new composite glass fiber reinforced plastics (GRP). [Fig. 2] Proving to be transparent to radio waves, as well as lightweight, strong, and weather resistant, GRP allowed radar on planes and ships to be protected, operational, and mobile. Lockheed corporation manufactured radomes with the newest technology using an interior and exterior reinforced structural tension shell of GRP held together with interior structural foam plastic—Lockform. [Fig. 3] “Foamed” into place between the inner and outer skin, Lockform’s key ingredient was plastic. Lockheed used this technique of foamed-in-place, double-shell construction for other structural aircraft parts, such as the ailerons and rocket exit doors of the Lockheed F94C *Starfire*. *Monsanto Magazine* editors noted in the article “The Nose that Sees” that this new manufacturing technique made possible “a great saving in man-hours” as “an aileron, which formerly had many ribs and doublers inside and hundreds of rivets to hold it together, now has almost no ribs and few rivets.”[15] Through the use of composite plastics of tension strength construction, industry saved valuable time and materials in the manufacture of structural components for aircraft.

The technology devised to sandwich an interior core between structural, high-strength tensile surfaces was first developed in plywood. [Fig. 4, Fig. 5] Using a plastic resin-coated balsa wood or foam core, the British manufactured the *Albatross* and the famous RAF *Mosquito* in 1940.[16] Monsanto resins added strength and durability to this original technology. As these resins were boil proof, corrosion proof, and waterproof, they could increase the time the plywood could be soaked in salt or fresh water, thus adding durability to the finished product. Setting at a normal 70-degree room temperature, these new high-performance resins were easily accommodated in the manufacturing process. The application of these resins was extended to the construction of wooden boats, including the PT–boat type, as well as

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14. Hubert Kay, “Monsanto Products Used in World War II,” Monsanto Company History WWII Products War Related, box 4, series 10, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.; “Doron: A Now-It-Can-Be-Told about Plastic Armor for American Troops,” *Monsanto Magazine* 22–25 (October 1945): 34.
15. “The Nose that Sees,” *Monsanto Magazine* 34, no. 4 (July–August 1954): 15–17.
16. Marvin E. Goody et al., *Building with Structural Sandwich Panels*, ed. Bernard P. Spring (Cambridge, Mass.: Massachusetts Institute of Technology, Department of Architecture, 1958), 7.

plywood fuel tanks.[17] Able to be mass-produced in seamless, thin, lightweight, continuously curved units that would not "create wind resistance or invite leaks," plastics provided the aircraft and shipping industries with a valuable new material from which to produce strong, durable, aerodynamic, waterproof, formed structures.[18]

The use of composite glass fiber reinforced plastics in the aircraft and shipping industries only further enhanced the benefits seen with plywood. In 1944 the U.S. Army built and tested the first airplane fuselage made of glass fiber cloth with a balsa wood core laminated with Monsanto's X–500 resin.[19] Test flights pronounced that the fuselage made of GRP achieved tensile strengths up to 46,000 pounds per square inch and were effectively stronger, and certainly lighter, than standard metal sections of aluminum or steel.[20] Plastic resins combined with glass or wood reinforcement showed great potential for long-term structural applications within the aircraft and shipping industries, and Monsanto was particularly interested in developing these technologies for future production.

Molded plastic and plywood products appeared to have distinct advantages to metals used previously for manufacturing large industrial products. U.S. molding methods using small press-formed or cast sheets of aluminum steel required that the materials be cut, fitted, and then fixed together to achieve complex shapes—a laborious and inefficient process that produced a great deal of scrap. These methods were inadequate to meet the increased demands of war. Large, structural plastic- and plywood-shaped sections provided greater continuity with fewer connections between parts, which was important for time and material efficiency. Monsanto resins contributed significantly to the effort to create new methods to achieve large-shaped products with greater structural integrity.

The plastics industry took great pride in their wartime accomplishments. Plastic protected the Allies against moisture, grease, dirt, saltwater corrosion, bullets, noxious gas, and even atomic fusion.[21] Companies such as Monsanto had created lightweight, mobile, time and material-saving, mass-

17. The latter were manufactured by Guillespie Furniture Company of Los Angeles. Fred Galen, "Extending Our Sting," *Monsanto Magazine* 24, no. 3 (June 1945): 18–19.
18. Ibid.
19. "Baked to Order in 8 Minutes," *Monsanto Magazine* 23, no. 6 (November 1944): 13.
20. Ibid.
21. Teflon plastic was discovered by DuPont in their search for a material that might protect against fluorine gas, an extremely corrosive substance used for gaseous diffusion for atomic weaponry. Teflon was used to protect valves and gaskets needed for manufacturing the atomic bomb. See Stephen Fenichell, *Plastic: The Making of a Synthetic Century* (New York: Harper Collins, 1996), 221.

producible plastics of continuous construction. They had proven themselves capable of developing a variety of new materials and technologies that were strong and durable enough to withstand the test of war.

When World War II came to an end, industry needed to shift production back toward domestic applications, and Monsanto would have to face another challenge, how to adapt these new plastic products, specifically designed for war, to peacetime production.

Domestic Plastics

In 1943, *Newsweek* announced in their article “Test-Tube Marvels of Wartime Promise a New Era in Plastics” that industry would create a “plastic postwar world.”[22] The wartime accomplishments of the plastic industry were presented to the public in popular magazines as the great hope to ensure the financial future of an expanding, post-World War II economy. There was a general consensus that no other innovation offered “such promise for rebuilding our war-torn industrial economy.”[23] Just as plastics had proven to be instrumental in the war effort, so too would they be at home, after the war.

Some in the plastics industry were very concerned that the historic record of inferior plastics used before and during the war, had tarnished the material’s reputation. But a clear sense that plastic could benefit and even transform life at home emerged before the war ended. *Newsweek* speculated,

> For the postwar world, there are promises of plastic houses, of plastic private airplanes, of thousands of other articles that will heighten the comfort of everyday living. Plastics may be the key to a new industrial era....They promise the production of basic materials tailor-made to fit the finished products.[24]

With plastics, a new world could be molded into the form of our desire. As the war ended, industry quickly shifted its attention to bring about this new synthetic world.

The media made clear how plastics could transform everyday domestic life: it could protect America at home on the domestic front using the same methods, materials, and techniques developed for war. Articles in *Life* magazine and *Better Homes and Garden* announced that it was domestic architecture

22. “Test-Tube Marvels of Wartime Promise a New Era in Plastics,” *Newsweek*, 17 May 1943, 42.
23. ”Plastics Tomorrow,” *Scientific American* 170 (March 1944): 105.
24. “Test-Tube Marvels,” 42.

that now needs to be protected.[25] [Fig. 6] *House Beautiful* devoted its entire October 1947 issue to plastics, promoting its benefits in ensuring a safe household. Titled "Plastics: A Way to a Better More Carefree Life," the issue featured an image of plastic wallpaper being drawn on by children and easily wiped off by Mom.[26] This was a new postwar Mom, at home, surrounded by her growing family. Newly developed plastics promised her a chance to "forget [she had] children" and live an "elegant, carefree life."[27]

Initially, plastics found their greatest use in the bathroom, laundry, and kitchen, "where the going is rough."[28] [Fig. 7] Easily cleaned, products like Formica and melamine cabinetry, vinyl flooring, polyethylene bottles and bowls, and phenol molded accessories proliferated in postwar years. "Damp-cloth" consumerism seemed the perfect weapon to fight the known enemies of dirt, grease, and grime in the home; plastic manufacturers and designers understood what products were needed for that war and were prepared to fight it, with little need to reinvent basic plastic manufactures or their fabrication processes. Durable, waterproof plastics were readily advertised to the public alongside the chemical industry's cleaners, detergents, and antiseptics.

Housework would become so easy that there would now be more luxury time to shop for glamorous synthetic outfits and cosmetics. The Monsanto advertisement "From finger-tips to wing tips" maintained that just as man had used plastics during World War II in the "conquest of the air," so women could now use plastics at home in the "conquest of man!" [Fig. 8] Plastic products developed for the wartime aerospace industry found application in women's clothing and cosmetics. Plastics had become the newest fetish in the war of the sexes, and Monsanto was not shy to promote its contribution.

Husbands, whose sex appeal supposedly derived from being rough, tough, and dirty, were frequently portrayed in advertisements spending time outdoors, in the yard or in the garage. Fiberglass plastics accompanied them, particularly in California, where backyard "do-it-yourself" (DIY) enthusiasts put together everything from furniture, surfboards, and swimming pools to boats and small aircraft made from this versatile new material. GRP, which used simple lay-up techniques, required only glass fabric

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25. "Indestructible Room: New Plastics Protect Walls, Furniture and Rugs from Ravages of Kids and Dogs," *Life*, January 14, 1946, 91; Christine Holbrook and Walter Adams, "Dogs, Kids, Husbands: How to Furnish a House so They Can't Hurt It," *Better Homes and Gardens* 27 (March 1949): 37.
26. "Plastics: A Way to a Better More Carefree Life," *House Beautiful* 89, no. 2 (October 1947): 120, 122-123.
27. Ibid., 138.

cloth, a mold, resins, and an idea. Once assembled, it could cure outside in the sun. [Fig. 9] Pre-manufactured, lightweight, inexpensive, transportable, structurally sound, and easy-to-assemble kits containing fiberglass plastic parts were made readily available to the suburban DIYer.

After the first fiberglass plastic car was built in 1946, men could presumably assemble their own motor vehicle in the backyard.[29] By the 1950s building your own car had become a *Popular Mechanic* phenomenon, as small shops developed prototype kits for the “Brooks Boxer,” the “Scorpion,” and the “Wildfire.”[30] Each car held the promise of beating, stinging, or burning one’s opponent—effectively, his neighbor—off the road. As Thomas Hines demonstrated, stylistically, the 1950s cars all had mean grilles and headlights to aggressively defend its occupants on the competitive suburban streets.[31] Even Detroit gave into the fad, churning out a fiberglass plastic Chevrolet Corvette in 1953 using Monsanto resins, which lent mass consumer appeal to this DIY trend. [Fig. 10]

Artists and architects also recognized the potential uses for mass-produced fiberglass plastics. Charles and Ray Eames and Eero Saarinen were some of the first to experiment with these materials immediately after the war, inspired by their earlier work with plywood.[32] The Eameses utilized fiberglass plastic panels made from wartime surplus to form chairs.[33] [Fig. 11] They produced various designs in plastic using Monsanto resins. The article “Furniture for Moderns,” featured in *Monsanto Magazine*, explored their simple chair designs for Herman Miller, manufactured at Glassform Inc. in Los Angeles.[34] Using glass rope fibers, they formed a fiber reinforced tensile mat filled with polyester resin that, when set between a matched-metal die, molded to the shape of a seated body. Light weight and integrally colored, these chairs were easily stamped out, trimmed, and mounted onto metal legs for mass production.

Saarinen’s Tulip Chair and the Eames’s La Chaise were perhaps the most structurally innovative fiberglass plastic chairs. The Tulip Chair appeared as if it were entirely made of plastic—supported on a

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28. Ibid., 125.
29. Jeffrey L. Meikle, *American Plastic: A Cultural History* (New Brunswick: Rutgers University Press, 1995), 196. Meikles’s text is a significant resource on the subject of plastics.
30. Ibid., 197.
31. Thomas Hines, *Populuxe* (New York: Knopf, 1986), 97.
32. Tensile strength construction techniques found significant application in furniture design before the war. The submissions of Charles and Ray Eames and Eero Saarinen to the 1940 Organic Design in Home Furnishings Competition at the Museum of Modern Art in New York were eventually developed by the Eameses for use in leg splints and molded aircraft sections during World War II.
33. The Eameses originally experimented with Fiberglas in their Case Study House 8, sponsored by *Arts & Architecture* magazine between 1945 and 1949.

central leg seemingly continuous with the chair seat and back. La Chaise used double tensile shell construction to achieve its greater strength and lightness, its exterior layers of fiberglass plastics sandwiching a resilient core of foam rubber and Styrofoam. The ethereal form was suspended effortlessly on spindly metal legs above the ground. Modulated to conform to the body in motion, the chair's amorphous plastic form provided multiple seating arrangements. La Chaise was designed to float like a cloud in defiance of the forces of gravity. It suggested the new fascinations of a mobile and temporal modern society.

A limit to the development of these chair designs—as well as to the development of cars, boats, and aircraft parts—was always the structural integrity of plastics. In the late 1940s and well into the 1950s, plastics failed to serve structurally and would seemingly never live up to the basic technical requisites of life safety. Fiberglass plastics offered much hope as a structural material, but it would take some time to meet government agency standards. Meanwhile, Saarinen's Tulip Chair relied upon a stand cast in aluminum that was subsequently sheathed in plastic to support the weight of a seated person. And the car industry maintained a steel chassis in their cars and returned to using steel bodies instead of plastic. Monsanto was concerned that "plasticity" would not continue to receive the public and financial support it needed to achieve its full potential. Therefore, the company took the initiative to make a substantial investment to secure the long-term promise of plastic and moved forward in a concerted effort to gain public and governmental support for their products.

The Monsanto House of the Future

Although Monsanto had generally succeeded transitioning wartime plastics to domestic production, by the mid-1950s it believed it was important to evaluate the extent to which plastics had made a marked impact on domestic life and reassess what opportunities remained for future development. After the war, Monsanto had successfully developed Chemistrand Corporation to produce acrylic clothing and nylon tire cables. They had manufactured All detergent and All dishwashing detergent. They had begun to develop

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[34.] "Furniture for Moderns," *Monsanto Magazine* 34, no. 1 (Jan.–Feb. 1954): 15–16.

interests in food manufacture and the production of Krilium soil conditioner.[35] They also maintained interests in the aircraft and shipping industries and produced antiseptics, laxatives, and aspirin. Many of their small-scale domestic products were developed from the raw materials used in wartime industry, which could be easily diverted back if the need arose. Monsanto had not, however, had much success developing large-scale plastics for domestic production.

Through research conducted under Director Ralph Hansen of Monsanto's Market Development Department in the Plastics Division, the company identified specific areas within the domestic economy that held promise for plastics. Hansen steered Monsanto's attention to the potential market in existing homes over twenty years old for the "do-it-yourself" and "please-do-it-for-me" customers, which accounted for over $7 billion dollars in home improvements.[36] Research indicated that consumers were most "susceptible" to being sold home improvement products when they first move into a home. With over 150 million people moving from one house to another between 1948 and 1953, Monsanto executives were interested in determining how to get them to spend their money for products made of plastic.[37] Plastic wallpapers, vinyl tiles, paints, and melamine furniture kits all proved well suited to the home improvement market. A product like the "do-it-yourself" fiberglass plastic pool was the perfect example of a large-scale home building kit designed to be easily installed in the yards of existing homes.

Of great potential was also the new housing market. This industry had been steadily declining in the 1950s due to "the small crop of persons of marriageable ages" born during the Great Depression, and this trend was estimated to continue through 1960.[38] By the 1960s, however, new housing starts were estimated to climb. "It is to this vast market," Monsanto proposed, "we should set our sights of advanced design, allowing the intervening period for the transition."[39] The company believed it necessary to develop "new ideas which will motivate the consumer desire into demand and finally into purchase." To that end, it

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35. Dan Forrestal, *The Story of Monsanto: Faith, Hope, and $5,000. The Trials and Triumphs of the First Seventy-Five Years* (New York: Simon and Schuster, 1977), 143.
36. Ralph Hansen, "Plastics in the Design of Building Products and Their Markets," quoted in R. K. Mueller, "Confidential—First Disclosure: The Plastics Division Presents the House of Tomorrow," 3 October 1955, 6–7, box 3, series 9, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.
37. Hansen, quoted in ibid.
38. Ibid., 3.
39. Ibid. Monsanto's confidential report maintained that annual average new households per year would drop from 1,525,000 between 1947 and 1950 to only 818,000 between 1950 and 1954. They cited the U.S. Census Bureau's projection of a further decline to 630,000 annual average households per year between 1955 and 1960. After 1960, annual average households were projected to increase to 1,500,000.

identified that “the responsibility of the architects and designers [was] to create ideas based on the psychological desires of the consumer.” As “consumers do not always know what they want and why they act,” the marketing department proposed the use of “intelligent experimental design, such as prototypes” to garner their approval.[40] Prototypes—used for furniture, toys, and auto interiors—had proven a successful marketing tool in obtaining quick acceptance of new products by both consumers and manufacturers. Monsanto believed it was possible to create similar desire on a much larger scale through the development of a housing prototype. Company executives at Monsanto had observed a trend in the construction industry toward modern design in schools and office buildings particularly on the West Coast. They believed that in time, “the ultra modern home” in plastic would be accepted. The company directed its efforts toward influencing that potential market.[41]

In May 1954 Monsanto approached Pietro Belluschi, dean of the Department of Architecture at the Massachusetts Institute of Technology (MIT), to assist in their marketing effort. MIT was selected due to its close “liaison” with the plastics industry.[42] Albert Dietz, a specialist in housing construction at MIT, served as chair of the Society of the Plastics Industry (SPI) Committee on Plastics Education and had experience developing plastic armor suits during World War II.[43] The Market Development Department in the Plastics Division of Monsanto provided a grant-in-aid to the Department of Architecture at MIT to organize a committee headed by Richard Hamilton, also at MIT. The committee worked with Dietz to produce and publish a document in 1955 that outlined current applications of plastics in the housing industry.[44] The document listed every use of plastics, from wet applied vinyl and acrylic roof coating and polyester film vapor barriers to the more obvious cabinetry laminates and toilet seats, and showed that plastics were in the household serving insulative, moisture protecting, and sanitary needs. It concluded, however, that they were not yet being utilized for structure.

Plastics had not yet made any major contribution to the building industry as structural materials. Fiberglass plastic and plywood sandwich panel construction, invented during World War II for the aircraft

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40. Hansen, quoted in ibid, 6–7.
41. Ibid., 7.
42. Richard Hamilton et al., *Architectural Evolution and Engineering Analysis of a Plastics House of the Future* (Cambridge, Mass.: Massachusetts Institute of Technology, Department of Architecture, 1957), 1. Rotch Library, Massachusetts Institute of Technology, Cambridge, Mass.
43. Miekle, *American Plastic*, 205.

industry, had achieved only minimal success in transitioning to the housing industry. In addition to design and fabrication problems, projects proved difficult to finance and distribute, which limited their success in the marketplace. Other house typologies invented in the postwar years, such as Buckminster Fuller's "all plastic dome" and General Electric's plastic "dream house" as well as more conventional prefabricated systems, likewise failed to have significant impact.[45] [Fig. 12, Fig. 13] Traditional wood and curtain wall construction dominated the industry since 1950, as noted by MIT in their 1958 summary report *Building with Plastic Structural Sandwich Panels*.[46] Plastics had made few gains as a structural component within any industry, including aerospace, as everyone had been "waiting for the role of the structural sandwich in the building industry to become better established before they made a major commitment."[47] Monsanto realized it was important to make a deliberate effort to cultivate the use of plastics as a structural element and invested in two extensive efforts toward this goal.

To develop and support interest in existing plastic material applications, on June 3, 1957, Monsanto opened its "brand-new" Inorganic Research Building at Creve Coeur Suburban Campus in Saint Louis, Missouri. The building was designed not only to house investigations in promising new synthetic materials but also to demonstrate the use of extremely conventional technological applications of plastics for the building industry. [Fig. 14] The architectural firm of Holabird, Root & Burgee designed Monsanto's new office building utilizing over eighty different applications of commercially available standard plastics.[48] In addition to demonstrating a wide variety of standard applications, the company's goal was to demonstrate the potential use of plastics in curtain wall construction. The architects designed and installed sandwich type curtain wall panels that used foamed-styrene cores with colored facing sheets of reinforced polyester resin. Monsanto wanted to propose how plastics could be formed into structural members for standard curtain wall construction that might eventually be able to support primary building loads.[49] However, the company recognized it might be difficult to manufacture plastics to be more

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44. *Plastics in Housing* (Cambridge, Mass.: Massachusetts Institute of Technology, Department of Architecture, 1955), 1–56, limited Access Collection, Rotch Library, Massachusetts Institute of Technology, Cambridge, Mass.
45. Betty Pepis, "People in Plastic Houses," *New York Times Magazine*, 23 November 1954, 50–51.
46. Goddy et al., *Building with Structural Sandwich Panels* (Cambridge, Mass.: Massachusetts Institute of Technology, Department of Architecture, 1958), 8.
47. Ibid., iii.
48. "P/A News Survey: Monsanto Reveals Present and Future of Plastics in Architecture," *Progressive Architecture*, June 1957, 89.
49. Goddy et al., *Building with Structural Sandwich Panels*, 3.

structurally sound than steel, and they accepted that "hybrid" plastic skyscrapers, with steel skeletons and plastic walls and floors "so light that the framework can be thinner," might be more feasible within ten or fifteen years.[50] To promote this potential, Monsanto installed at Creve Coeur full louver-type acrylic windows, plastic-faced concrete blocks, and styrene extrusions fitted in steel-frame channels to support interior reinforced polyester partitions.

If Monsanto's Inorganic Research Building at the Creve Coeur campus exhibited conservative applications for plastics available in everyday commercial building, its proposal for the Monsanto House of the Future sought to push the possibilities of using plastics in hope of establishing a completely new architectural typology. Mueller remarked in a talk before the Building Research Institute in Washington, D.C., in 1954 that plastic held the potential to completely revise the "architectural index" of the time. He predicted, "plastics play a significant role in a new American style of building architecture because of inherent features of plastic materials and their adaptability in any type of design."[51] Plastics would be the material of the future and had the potential to redefine architecture and the habits of modern living. Douglas Haskell, architect and editorial chairman of *Architectural Forum* argued in his September 1954 article, that plastics would generate a "second 'modern' order...to which today's 'modern' will be just an antecedent."[52] This "second 'modern' order" was to be derived on the basis of plastics' "inherent features" and would signal a departure from the current trend favoring the manufacture of steel frame, mechanically fastened panel construction, which used relatively little plastic. As Haskell remarked:

> Today's typical "order," as Mies van der Rohe says, is the skeleton frame....Tomorrow's structure may be typically all "skin." Its skin may be formed to become its shell *and* its interior columns of cellular structure....A single continuous envelope of a thin sandwich material may yield structure and enclosure; resistance to destructive forces from outside; solidity or porosity; control of light and view; insulation for heat and sound, color and finish—all characteristics we now impose separately….Future buildings may be as thin as egg shells.[53]

Continuous tension skin eggshell construction as presented in 1950s architectural discourse sought to promote an alternative building typology in contradistinction to the traditionally accepted modern practice of "skin and bone" architecture. This was not the first time continuous tension skin eggshell construction

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50. "Big Impact, Bigger Potential," *Newsweek*, June 4, 1956, 80.
51. Mueller, "Confidential—First Disclosure," 10.
52. Douglas Haskell, "In Architecture, Will Atomic Processes Create a New 'Plastic' Order?" in "Building in the Atomic Age," *Architectural Forum*, September 1954, 100.

was proposed in architectural practice: Frederick Kiesler had already conceived this ideal method of construction in his 1933 Space House project.[54] [Fig. 15] Kiesler came out strongly against rectilinear panel and frame architectural practices, but he never had technological or industrial support for his vision. After World War II, however, the plastics industry had clearly realized the potential to develop and exploit the technology behind this architectural concept, which well represented the material characteristics of plastic over those of steel.

Knowing Kiesler's work, Haskell promoted the "inherent" material characteristics of plastics that, he wanted to believe, were only further enhanced by claims made by the atomic industry. In a special report by *Architectural Forum* on "Building in the Atomic Age," information gathered from several experts in the field of atomic energy maintained claims that plastics had "proven" likely to be stronger than steel and completely fireproof when exposed to nuclear radiation.[55] In the report, Dr. Phillip N. Powers, director of Monsanto's Atomic Project, supported the long-term manufacturing benefits of the use of radiation or fission products from new nuclear energy reactors planned by Monsanto.[56] The company had been a significant contributor to the Manhattan Project during the war, and as it continued to research and develop atomic energy Monsanto promoted the potential use of atomic radiation to enhance plastics.[57] Enamored by Monsanto's claims, Haskell predicted:

> Chemical, electronic, [and] radionic manipulation [would become] the *dominant process* in 'building,' which [had] hitherto been dominated first by handicraft and later by mechanical joinery. In over-all shape, buildings created by this new extension of *monocoque* principles, already familiar in the construction of airplanes and storage

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53. Haskell, "In Architecture," 100. Emphasis in the original.
54. Kiesler's Endless Theater project (1924-1926) presented at the International Theater Festival in New York, 1926, originated the concept of a dual-shell glass and steel egg shaped structural skin, and developed the concept of continuous tension shell construction in his Space House project for the Modernage Furniture Company in New York. Kiesler's structural cocept was informed by innovative bridge design. Eugéne Freyssinet, the French engineer and Robert Maillart, the Swiss bridge builder explored tension shell construction using steel reinforced concrete in the 1920s and 1930s. The structural concepts presented by Douglas Haskall and explored by MIT for MHOF were originally conceived for glass, concrete, and steel composite materials—adapted to new plastics.
55. "Does Atomic Radiation Promise a Building Revolution?" in "Building in the Atomic Age," *Architectural Forum*, September 1954, 94.
56. Ibid., 96.
57. Dr. Charles A. Thomas, the director of central research and vice president of Monsanto, had completed vital research and solved production problems as director of the Clinton Tennessee Laboratories working on radioactive isotopes. Monsanto took control over the Clinton Laboratories from the University of Chicago in 1945 and also assumed construction and supervision of the Atomic Energy Commission lab in Miamisburg and Marion, Ohio. Monsanto was an active force in the development of atomic research and production, receiving numerous wartime and postwar contracts. See Dr. M. D. Whitaker, "Manhattan Project, Oak Ridge, Tennessee—Name of Dogpatch," in "Nucleonics," *Monsanto Magazine* 24, no. 6 (1945): 16. See also Curtis, "Monsanto in World War II," 20.

> tanks, may well harmonize still better with the world of ships, planes and hangers than with today's typical rectangular 'frame' buildings.[58]

Haskell hypothesized that in the atomic age a new modern architecture would utilize gamma fission radiation to develop the material characteristics of plastics for use in continuous, *monocoque* structural skins.[59] These skins would bring about the replacement of those mechanisms that had previously supplanted handcraftsmanship. They would prove more appropriate to the science and speed of the modern, atomic age.

To supplant the technological supremacy of the steel industry, Monsanto recognized that it needed to make significant advances in engineering and construction practices favoring plastics. In order to achieve this goal, Monsanto sought to derive an authentic technology particular to the "inherent properties" of plastics. Hansen, citing from the program brochure of the MIT 1955 Summer Conference on Plastic Housing, maintained:

> Because many of the inherent properties of plastics differ widely from those of the traditional materials of the building industry, designers, fabricators, and producers entering this field face many new problems....As a result, it becomes important for [them] to develop a thorough understanding of the material's basic properties and of the potentialities of new engineering combinations.[60]

Monsanto developed its interests in the House of the Future specifically to resolve the problems of design and fabrication thought to be particular to plastic materials. R. C. Evans, Monsanto's Plastics Division marketing director, explained, "the design [of MHOF was] intended primarily to prove-out architectural and engineering concepts utilizing the inherent properties of plastics and thus stimulate the use of plastics in achieving more satisfying ways of living five or ten years [in the future]."[61] Monsanto had hoped to instigate interest, gain support, and prove the potential of a new architectural vocabulary that utilized and justified continued development, production, and marketability of its plastic materials. In particular, it intended to promote the use of "plastic sandwich panels fabricated entirely of one material" as "the

58. Haskell, "In Architecture," 100. Emphasis in original.
59. Monocoque is an aeronautical engineering term for a structure, such as an airplane fuselage, that has an outer covering in the form of a rigid skin or shell designed to bear all or most of the structural stresses.
60. Program Brochure, Massachusetts Institute of Technology 1955 Summer Conference on Plastics in Housing, quoted by Ralph Hansen in Mueller, "Confidential—First Disclosure," 2.
61. R. C. Evan, quoted in "News for Release—Immediately, Press Book, From Plastics Division Monsanto Chemical Company, Springfield, Massachusetts," June 1956, 3, History, box 3, series 9, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.

answer to the curtain wall problem."[62] Monsanto hoped to suggest—with its prototypical design developed through strategic marketing and well-targeted investment—nothing less than a new architectural typology.

Accepting the challenge to develop and explore the potential of plastic architecture, MIT architects and engineers sought to formulate new designs, methods, and technologies that "dictated a sharp break with traditional architecture."[63] Generous financial support for their project initially came specifically from Monsanto and from the Corning Fiberglas Corporation. Not surprisingly, MIT would eventually conclude that the parameters defined as "inherent" to plasticity that could provide a "sound 'envelope for living' in an infinite variety of contemporary forms" would be achieved with high-strength tensile skin technology using Fiberglas structural sandwich panel plastic construction.[64]

As Hamilton and Dietz began to investigate the design for MHOF, in conjunction with Marvin Goody, an assistant professor of architecture at MIT, they produced a formal statement on the project's architectural evolution. They effectively declared their hope to invent a plastic "aesthetic" that did not "degenerate...into the realm of substitute materials" and instead "design...their product according to the dictates of the material."[65] The architects were aware that they were dealing with a material, the shape of which could be anything from flat to completely amorphous, depending on the molding process involved."[66] As Hamilton noted, "this was clearly an instance in which the designers were faced with a freedom that was all too complete."[67]

Although plastics theoretically supported the "freedom" to be formed without limit—tailored to one's desire—the MIT architects believed designing "form for form's sake," by "determining the shape and stuffing the function of living into it was not going to solve the problem of the ideal home"; this process, they believed, could not "adequately solve the needs of a mass client and in all likelihood would resolve in

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62. "General Background Information, Monsanto Chemical Company 'House of the Future,'" 1957, 4, Exhibits and Visual Arts (House of the Future), box 3, series 9, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.
63. Richard Hamilton, et. al., "Architectural Evolution and Engineering Analysis of a Plastic House of the Future," 1 June 1957, Rotch Library, Massachusetts Institute of Technology, Department of Architecture, Cambridge, Mass., i.
64. Mueller, "Confidential—First Disclosure," 1.
65. Hamilton et al., "Architectural Evolution," 2.
66. Ibid.
67. Ibid.

manufacturing difficulties."[68] Instead, they insisted that "the ultimate form had to be one that was peculiar to the plastics fabrication process" and would be derived in response to its material effects.[69]

Relying on technological materialist claims, they promoted an architectural process that was governed by the appropriate use of materials over any aesthetic, programmatic, or functional requirements. They argued their point by asserting that plastics performed best in compound curve or shell structures because they could be "easily molded into thin hull-like components" using the minimum amount of materials.[70] Curved, statically indeterminate forms achieve rigidity and stability from their shape and thereby theoretically use less material by weight to achieve the same stability as flat, rectilinear structures. This works for all materials, but plastic's malleability can achieve compound curves more readily. As plastic is typically lighter than most construction materials, there are also structural benefits to be gained by its use in curved forms.

It became clear, however, that when used in more traditional, rectilinear, statically determinate forms, plastics have a much more difficult time than other materials achieving rigidity and stiffness necessary for structural purposes. As Dietz realized, what limited the use of plastics in the 1950s was their ability to achieve rigidity and stiffness necessary to withstand deflection loads while still maintaining (like steel) "plastic flow or yielding" in areas of concentrated stress.[71] As plastics were developed for rigidity, they lost flexibility and thereby tended to fracture abruptly, posing life safety issues. Plastics, even when reinforced, did not perform well under point loading, typical of conventional construction. To minimize point loading and provide a strong, rigid surface without excessive use of material (which would increase the overall weight of the structure), plastics needed a high modulus of elasticity. In the end, plastics were better suited to continuous curved compound structures due to the fact that they could be easily shaped and structurally required the benefits of compound curved forms to become viable structural building materials. In effect, the choice to use plastic governed the formal requirements of the architecture—at least, so it seemed in theory.

Non-compound curved forms were discussed by the MIT architects in a formal statement written prior to the development of the final design for MHOF, but were not considered practical. Structural tent

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68. Ibid.
69. Ibid.

projects that could be easily mass-produced in kits and readily distributed to a variety of sites had some promise. It was determined, however, that they posed too great a risk, as they produced irresolvable technical problems of security, piercing, flutter, and stability in high winds, among others; they also created heating and maintenance problems considered insurmountable for the family's "space budget."[72] MHOF needed to be an economical "space age" house sized appropriate for a growing family's income. With long-term growth potential in mind, the MIT architects also proposed a cellular house that could expand in modular increments with flat sandwich panel walls and dome roofs in honeycomb configuration. This typology, however, seemed unlikely to respond well to one essential question posed by the researchers: "Could the site come and go as it pleased under the house?" The team was interested in a modular house formulated as a kit of parts that could accommodate various site conditions. Although a honeycomb house might be designed to meet that criterion, it would not necessitate a new structural system specific to plastic: Its flat wall surfaces would not adequately showcase plastic's potential.

The MIT architects agreed on a design in which "the compound curve might be the total enclosure." They favored the idea of "a continuous curving surface [that] could result in the floor extending to form the wall and finally the roof and ceiling." As they reported to Monsanto: "This was a concept that very few structural systems and materials are capable of accomplishing. The ideal form had to be one in which the enclosing material was of a continuous surface; the floor, walls, and roof all being of the same geometry."[73] This, in effect, was the form in which plastic might best exhibit its promise, unique from and exclusive of most other materials. If Monsanto could cultivate desire for this new "plastic aesthetic" along with the technical specifications to prove it was achievable, it might be able to ensure the long-term market success of its product.

Monsanto's Market Development Department, in conjunction with MIT, developed criteria for an ultra-modern house of the future. They maintained that it must be designed for "ultimate spatial quality and usefulness," "flexibility of size," "economical fabrication to enable the resulting building to be as large as possible," "ease of erection," "flexibility of siting," and "suitability in the landscape"; in addition, the design

70. Ibid.
71. A. G. H. Dietz et al., "Engineering the Plastics 'House of the Future,' Part I," *Modern Plastics*, June 1957, 146.
72. Hamilton et al., "Architectural Evolution," 3.
73. Ibid.

“would not hinder the individual’s ability to reflect his personality.”[74] In response to these criteria, MIT designed MHOF using modular “continuous” shells that formed roof, wall, and floor. These U-shaped shells with glass infill ends called “bents,” were limited to eight feet by sixteen feet for transportability. Their curved surface and sandwich construction rendered them “capable of absorbing extreme shell stresses with a minimum amount of material.”[75] These segments were designed to resemble an airplane wing cantilevered off a fuselage, where the symmetrical forces from each wing are carried indeterminately and continuously through the central core. [Fig. 16] In the article “Engineering the Plastics ‘House of the Future’” Dietz explains that “this idea was borrowed from airplane designers, who carry the wing structure straight through the fuselage and avoid putting wing stresses into the fuselage. The wing is one big unit.”[76] In MHOF, “the floor and roof sections were designed [similarly] as units so that the load is carried straight through and not transmitted to the columns to any great extent except for the vertical load.”[77]

The structural U-shaped shell “wings” were to connect together through a square central mechanical and plumbing core. The core housed the kitchen, bath, and circulation systems, while the dining room, living room, and bedrooms were fully enveloped within the wings. In essence, the design concept was to inhabit the space between the compound shell curves of an airplane wing, designed as a lightweight kit of parts to minimize construction time and materials in a form modulated to the habits of everyday life. Wartime advancements in easy-to-install, mass-producible, unbreakable, lightweight, waterproof, continuously molded plastics were transmuted both conceptually and aesthetically into a new, modular, domestic spatial tectonic.

Like a fiberglass plastic pool, MHOF could be put together by fathers and sons in their own backyard. The composite Fiberglas plastic bathroom core was built as one continuous lightweight element that came fully equipped and ready to install. Inside the walls the U-shaped bents were what MIT architects described as a flexible “system of sub-frames”: “The man of the family could then demonstrate his do-it-yourself creativity by designing within the structural framework of the shelter the eight window walls of the basic house.”[78]

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74. Ibid., 2.
75. Ibid., 6.
76. Dietz et al., “Engineering the Plastics ‘House of the Future,’” 150.
77. Ibid.
78. Hamilton et al., “Architectural Evolution,” 6.

Expandability was achieved through the addition of components, and flexibility was ensured by multiple layout possibilities. Although typically featured on flat terrain, options included houses suspended above the ground on concrete compression cores. [Fig. 17] As in Buckminster Fuller's Dymaxion House, mechanical and electrical systems were centralized and located in the core. For MHOF, this created a zone in which all heavy equipment could be installed structurally independent of the plastic bents.[79] The architects suggested that "by adding a second...foundation core, an increasing number of cantilevered wings could be added to the original structure." These expanded versions of the house "could reflect the added leisure time available to the family [by] providing do-it-yourself hobby rooms, TV areas, sewing rooms, etc."[80] [Fig. 18] MHOF was designed with the premise in mind that it could go anywhere and expand infinitely, on a site that might "come and go as it pleased under the house"; the structure "might in its entirety be lifted off the ground if the site so required."[81] The cantilevered wings were curved to provide stiffness against buckling and sloped to match changing bending moments. They formed "strong, light, and stiff box-shell monocoque structures [while] at the same time they were the expression of the structural function of the wings."[82] They were a symbol of their own structural integrity, held up on a concrete plinth as a representation of the promise of plastic form.

In the execution of the MIT design, the architects and engineers faced numerous problems. The continuous U-shaped bents eventually had to be discarded for practical reasons concerning their structure, manufacture, and distribution. A joint was established between a lower and upper bent, allowing for more reasonably sized modules, better structural independence for each bent, and greater integrity against thermal effect and wind loads.[83] The stiffness of the plastic materials had to be significantly increased, and according to Dietz, "to get this stiffness, the sections had to be made deep enough to have a large moment of inertia without using a tremendous quantity of expensive reinforced plastics."[84] In effect, the material resisted their ideal conception of "plasticity."

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79. Dietz et al., "Engineering the Plastics 'House of the Future,'" 148.
80. Hamilton et al., "Architectural Evolution," 6.
81. Ibid., 5.
82. Ibid., 21.
83. Dietz et al., "Engineering the Plastics 'House of the Future,'" 150. As plastics of the time had a thermal expansion two to eight times as large as other construction materials, the differential between the heat of the sun and the air-conditioned interior created uneven distribution of buckling forces, which caused twisting. Wind forces also created twisting and uplift, as did earthquake forces.
84. Dietz et al., "Engineering the Plastics 'House of the Future,'" 150.

To solve all these problems of structural force, a box girder system was adopted, providing a structural frame above the concrete core to which the cantilevered wings, roof, and floor were then attached. [Fig. 19] The floor and roof were designed as large, hollow girders, and four laminated-wood spandrel beams were added to the roof at the core to transfer the loads. The floor was made independent from the bents as a sandwich panel supported over a wood beam, and the ceiling had to be soffited. Reinforced plastic ribs were added as needed to increase stiffness. Reinforced columns were designed at the four corners of the core to support the roof and sunk down into a reinforced concrete foundation; they were then stiffened in the foundation area by large gussets.[85] In the end, some of the interior partition walls also needed to be used as permanent structural panels to transfer lateral forces. A series of steel bolts, connectors, and machine screws were used in combination with adhesives to attach the modules together, then smoothed over to simulate "continuity." In effect, MHOF was framed as a box with cantilevered "curved" plastic floor and roof elements that needed extensive conventional reinforcement beyond compound curve "plasticity" to achieve its physical form. It was not the embodiment of an idealized engineering of plastics' "inherent properties" but instead the demonstration of an effort to achieve *monocoque* form through fairly conventional technologies of the time using composite plastics.

Although MHOF used many traditional construction technologies in combination with plastics, numerous tests were still necessary during the design phase to ensure and prove the strength of the proposed structural systems. [Fig. 20] Test bents were constructed at the Monsanto plant in Springfield, Massachusetts. They were subjected to strength tests using barrels filled with water to simulate the weight of 150 people packed into each room or about 5 feet of snow on the roof.[86] Thermal tests were also conducted using oscillating sprinklers that exposed the bents to 186 degree temperatures. The ultimate test of MHOF, however, was carried out through the exhibition of the full-scale prototype.

In the August/September 1956 issue of *Monsanto Magazine*, images of the architect's plastic design model of MHOF appeared along with the question, "When can we expect this project to be brought down out of the clouds and planted for people to really see and believe?"[87] This visionary project was scheduled to descend to earth the following year. However, at a price of $1 million, Monsanto realized

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85. "Plastics—Shaping Tomorrow's Houses?" *Architectural Record*, August 1956, 210.
86. A. G. H. Dietz et al., "Engineering the Plastics 'House of the Future,' Part II," *Modern Plastics*, July 1957, 127.

that their prototype for the House of the Future would not likely be mass-produced for the market well before it was even built. It would only be “a show piece designed to show the way to greater use of plastics.”[88] [Fig. 21] Mueller announced to the company in October 1955 that even the basic plastic materials for a 30,000 pound house, at 50 cents per pound, would start at a cost of $15,000—already well beyond most peoples’ budgets at the time—and that the actual cost of the finished house was indeterminate. MHOF was to be a “demonstration and test house,” exhibited where it might have greatest effect. “The encouragement which this house would give to various people interested in plastics,” Mueller maintained, “would be sufficient to push along the use of plastics in housing.”[89]

Disneyland, in Anaheim, California, was selected as the site for the MHOF demonstration house, based on the location’s potential to test the market and gain the greatest amount of publicity for the project. Monsanto had already established a successful relationship with Walt Disney. Monsanto’s Hall of Chemistry had been in operation at the amusement park from the time of Disneyland’s founding in 1955, and Monsanto believed the exhibit was successful in demonstrating the newest in chemical production. The company had large investments in California, due not only to the state’s proximity to natural resources but also to its growing aerospace industry. Cognizant of the fact that Disneyland, located “in the heart of the great Southern California population area,”[90] attracted visitors from every state, Monsanto executives set out to “capitalize on the flow of people and their reactions over...years of exposure.”[91] MHOF was designed to be tested by millions of people.

Disney conceived his theme park as a place that would incite nostalgia for the past and childlike adventurism of the future. “Here you leave today and enter the world of yesterday, tomorrow, and fantasy,” declared Disneyland’s 1955 dedication plaque. Incorporating their experience from animated film, Disney and his team of “Imagineers” built a fantasy-filled, consumerist entertainment mall based on

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87. “Monsanto’s House of Tomorrow,” *Monsanto Magazine* 36, no. 4 (August–September 1956): 17.
88. “Like most explorers on the frontier of the unknown, Monsanto is ‘traveling light.’ That is, at this time, it does not plan to make or sell duplicates of the House of Tomorrow.” Ibid.
89. R. K. Mueller, Monsanto Chemical Company, St. Louis, to Mr. Persechini, 6 October 1955, 2, History Folder, box 3, series 9, Monsanto Historic Archives Collection, Washington University Library, St. Louis, Mo.
90 Robert K. Mueller quoted in “News for Release-Immediately, Press Book,” From Plastics Division, Monsanto Chemical Company, Springfield, Massachusetts, June 1956, 2, History, box 3, series 9, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.
91 Monsanto Chemical Company, Plastics Division, “Project Effectiveness to Date,” *Directory: The Monsanto “House of The Future,”* Summer 1957, 21, Executive Report, box 1, series 9, Monsanto Historic Archive Collection, University of Washington, St. Louis, Mo.

studies of a wide variety of successful world's fairs, theme parks, and urban centers. Disney tapped into an unfulfilled longing in Americans to escape from the harsh realities of urban life and to spend the day with the entire family in a miniaturized, walkable city full of entertainment and adventure.

The fantastic structures that comprised the new urban theme park were constructed primarily of complex steel and wood frames covered with wood lath and plaster sheathing. As the *California Plasterer Journal* noted in July 1955, "Only these products could successfully answer the call for materials to fit the many shapes to be expected of a Walt Disney design enterprise."[92] The Fantasyland Castle and Snow Mountain (later replaced by the Matterhorn) were not shaped of stone or earth despite vague appearance. What a building or theme event looked like had nothing to do with how it was built or what materials were used in its construction.

Many of the themed areas inside the park—Main Street, Fantasyland, and Frontierland, for example—were based on historic neighborhoods presented on television or in the movies. Tomorrowland, however, where Monsanto leased exhibition space, was created to present the future and proved to be the most challenging area of the park to conceive and construct. When it opened in 1955, little more than a bunch of balloons hid the lack of invention demonstrated by a series of dressed-up storage sheds that comprised the "carnival rides" of Tomorrowland.[93] Disney had originally intended his futuristic city to showcase innovations in technology and industry. His Imagineers had dreamed up monorails and rockets streaming throughout a new utopian city raised off the ground on stilts. None of these images, however, were as yet the least bit constructible. Anxiously awaiting the arrival of new technology, Disney welcomed and supported Monsanto's intent to design a Fiberglas plastic House of the Future—especially one that might provide the technology for an inexpensive, malleable building typology well-suited to space-age fantasy.

Late in 1956, Walt Disney contacted Imagineer John Hench to coordinate with Monsanto and MIT on their housing plan. Walt Disney sited MHOF just outside the entrance to Tomorrowland marking the important transition from the Fantasyland Castle. [Fig. 22, Fig. 23] Inside the boy's bedroom, visitors

[92] "Disneyland: Fabulous Wonderland Opens in Anaheim; Lath and Plaster Used Extensively in Producing Structures for Show Place," *The California Plasterer* XXX (July 1955): 15, Walt Disney Archives, Burbank, Calif.
[93] Karal Ann Marling, "Imagineering the Disney Theme Parks," in *Designing Disney's Theme Parks*, ed. Karal Ann Marling (Montreal: Canadian Centre for Architecture, 1997), 143.

would have a clear view of Snow Mountain.[94] MHOF would be the first significant attraction at Tomorrowland, which held the potential to fulfill the utopian dream of a new domestic architecture.

The house set down in Disneyland in June 1957. Premanufactured and shipped from the Winner Manufacturing Company in Trenton, New Jersey, preparations for construction had taken three months. The shells proved to be a challenge to build, as ensuring continuity at the connections required extreme accuracy. Each bent was formed by first building a precisely scaled wooden mold of the desired shape. A negative mold was then taken from the original using polyester resin and Fiberglas cloth. The negative mold was used as a surface to build up an actual GRP bent using hand lay-up techniques. Ten piles of woven Fiberglas mat were layered between polyester resins, and once cured each shell was insulated and stiffened with rigid-polyurethene foam, sprayed on the inside. Another, thinner, interior layer of GRP was applied by hand and was cured at room temperature.[95] The structural bents were then installed with a crane and finished on the site—hand trimmed, sanded, epoxied, bolted, and riveted together. [Fig. 24] The assembly process took a total of three weeks. The process was extremely low-tech and labor intensive. The panels for floors, ceilings, interiors, and windows all amounted to more pieces than intended. In the end, the actuality of production and construction contradicted the image of the sleek, time-and-materials-saving, modern, plastic kit of parts. MHOF was not manufactured at a push of a button.

Nevertheless, image is sometimes all that matters, and, ultimately, the house proved to satisfy "space age" fantasies of the future. [Fig. 25] A reporter for *The New York Times*, in an article titled "4 Wings Flow from a Central Axis in All-Plastic 'House of Tomorrow,'" noted that, due to its curved white walls, the house "with the drapes drawn [gave] one a feeling of being in the cabin of a rocket ship headed for Mars."[96] Due to its small size, the reporter considered MHOF somewhat "claustrophobic" for the man of the house, but for the woman, it was considered a dream come true. Everything could be operated from a central command center: "The kitchen sink in this arrangement becomes practically a control

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[94] Jack E. Janzen, "The Monsanto Home of the Future: Putting the 'Tomorrow' in Tomorrowland," in *The "E" Ticket* (Winter 1991–92): 12, 15, Walt Disney Archives, Burbank, Calif.

[95] See C. G. Cullen, "Fabricating the Structural Components of the All-Plastic 'House of the Future,'" *Plastics Technology* 10 (October 1958): 921–27. See also Meikle, *American Plastic*, 209–10, for more on fabrication techniques.

[96] Gladwin Hill, "Four Wings Flow from a Central Axis in All-Plastic 'House of Tomorrow,'" *The New York Times*, 12 June 1957.

tower, where she can maintain surveillance over three of the four rooms in the house. By pushing an array of buttons she can regulate practically everything but her husband."[97] There was even a button in this new space capsule equipped to control the air, with different scents for each room depending on changing environmental factors. MHOF had all the gadgets of a fantastic science exhibit. The house of the future came with all the promise of hi-tech automation. The kitchen was outfitted with three refrigerators (one specifically for irradiated produce), a range, and laundry equipment. [Fig. 26] All of these appliances were able to slide within walls, drop beneath counters, or raise and lower from the ceiling. The kitchen was designed to disguise its appearance "because it is fully viewed from the dining room and the living room." As for the furnishings, the most up-to-date comforts were distributed throughout the home. From tables and chairs to sliding panels, rugs, fabrics, cups, plates, countertops, pillows, drapes, sinks, toys, phones, and dolls, everything needed for a comfortable home life was included, and manufactured in plastic. Even if consumers could not yet purchase a Monsanto House of the Future, they could surround themselves in furnishings made of this "revolutionary" material.

Encased in the comforts of a modern home, the project provided a sense of security that might pacify latent fears in a Cold War society. Exhibited next to the castle of Sleeping Beauty, this house projected the fantasy image of a space lander or mobile bomb shelter. The house provided for domesticity within a (theoretically) transportable kit of parts, tailored to a future lifestyle of speed and push-button efficacy. MHOF advertised future consumption as the means to safe, modern living under the guise of a theme park tourist attraction. MHOF was an exhibition house for industry that masqueraded as an amusement ride, selling tickets to incite desire. And it was an extreme marketing success.

Over 435,000 people visited the Monsanto House of the Future within the first six weeks of its grand opening. Media coverage was extensive and included everything from local television spots to articles in *The New York Times* and *Time* magazine. Monsanto estimated that 5 million people visited the house per year, which translated into "10 million footsteps in 12 months" testing the vinyl tile floor.[98] In 1957 Monsanto estimated further, after "two years of 'scientific farming' by a staff of public relation

[97] Hill, "Four Wings Flow."
[98] Monsanto Chemical Company, "Press Book," in *Directory, The Monsanto "House of the Future,"* 17 July 1955, Executive Report, box 1, series 9, Monsanto Historic Archive Collection, University of Washington, St. Louis, Mo. Although perhaps only 6 million people actually visited MHOF in the first three years, by the time it was removed from the park in 1967, over fifteen million visitors had seen the attraction.

specialists from 13 companies, [that] a half-billion readers, viewers and listeners...[had] been exposed to stories of Monsanto's House of the Future."[99] [Fig. 27] In 1958, Disney's Consumer Relations Division took an exit poll for Monsanto from visitors to MHOF.[100] Of the 1,008 people surveyed, over 95 percent found the house to be entertaining, educational, or both. The kitchen and bathroom were considered by far the most interesting features of the house. The greatest complaints were that MHOF was too small, cold, and not very homelike. Nevertheless, over 96.9 percent of those surveyed truly enjoyed their visit to the House of the Future, even if only slightly less than 63 percent of them actually knew that Monsanto had sponsored the attraction.

Monsanto's efforts to get the most from their investment continued for years. The house was renovated twice, with all new interiors created to display more homelike styles in contemporary (plastic) living. In 1958, a replica of the plastic shell traveled to the Brussels World's Fair and was exhibited in the "Face of America" pavilion.[101] According to Monsanto, in 1962, Russia announced that it had "achieved a construction breakthrough and built the 'first plastic house,'" a photograph of which bore "more than just a casual resemblance" to the House of the Future at Disneyland.[102] Monsanto was delighted by the success of its project, as compared to the Russians; MHOF had gained significantly more attention than its foreign counterpart. Of course, neither the Russians nor the Americans can be credited with the first "plastic" house; the French had already built a plastic exhibition house in 1955 by Ionel Schein."

Despite the renovations and publicity, by 1968, MHOF, and Tomorrowland in general, were no longer futuristic enough. Walt Disney decided to update Tomorrowland and, with the help of Charles Allen Thompson from Monsanto, MHOF and the Halls of Chemistry were replaced by another Monsanto attraction, "Adventures thru Inner Space," which featured a multi-media projection journey into the "World of Molecules and Atoms."[103]

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[99] Monsanto Plastics Division, "A 1957 Summary and Analysis, and 1958 Forecast of MHOF Publicity," Special Report to D. J. Forrestal, September 1957, 1, History, box 3, series 9, Monsanto Historic Archive Collection, Washington University Library, St. Louis, Mo.
[100] "A Disneyland study for Monsanto Chemical Company Hall of Chemistry and House of the Future," Customer Relations Division, Disneyland Inc. for Monsanto Chemical Company, October 1958, Monsanto House of the Future folder, Walt Disney Archives, Burbank, Calif.
[101] Monsanto Plastics Division, "News for Release," 1958, 1–2, History, box 3, series 9, Monsanto Historic Archive Collection, Washington University Library, St. Louis. Mo.
[102] "Right to the End, This Plastic Structure Proved that It Was a House with a Bounce," *Monsanto Magazine*, March 1968, 25.
[103] "Right to the End," 25.

MHOF was dismantled after receiving over twenty million visitors. The demolition crews, however, were "baffled when [a] 3,000 pound steel headache ball simply bounced off the plastic walls" of MHOF.[104] Workmen were challenged to demolish the project, employing "torches, chainsaws, jackhammers, clam shovels and virtually every tool in their armament, to no avail."[105] [Fig. 28] An article in *Monsanto Magazine* described:

> Eventually choker cables were used literally to squeeze the big plastic modules into pieces small enough to be trucked away. Attempting to dislodge the house from its concrete pad, the wreckers found that the half-inch steel anchor bolts broke before the glass fiber-reinforced polyester material.[106]

In their very efforts to prove plastics could be structurally durable, the architects and engineers hired by Monsanto designed a modular kit of parts that could hardly be disassembled. All good intentions behind a flexible, interchangeable, mobile, and transportable architecture inspiring the birth of a new, second-order modernism were ultimately undermined by the very insistence upon durability, permanence, and fixed-stable form.

The plastics industry had its own agenda: to prove its usefulness in a building economy dominated by steel. Toward that goal, it may have proved plastics to be extremely strong, but it hardly proved them to be cost-effective. The MIT architects were disappointed that they were never able to mass-produce the Monsanto House of the Future. They came to recognize that national and state codes were not going to accommodate plastic as a structural material. As Dietz understood, there were still no industry standards for plastic structural materials, because structural plastics had not been around long enough to be tested for long-term viability against weathering elements over the course of a building lifetime.[107]

Plastics continued to find use in everyday domestic products and in the building, shipping, and aerospace industries, but they never garnered acceptance on the scale Monsanto and MIT had envisioned. Even in the 1970s when fiberglass plastics found their true calling at Disney World, they were mostly used throughout the theme park as skins to sheath frame construction. Compared to much of Disney architecture, MHOF was significant in that it was not a frame structure wrapped with a free-for-all

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[104] Ibid., 23.
[105] Ibid., 25.
[106] Ibid., 25.

skin. The skin had a relationship to its structure—it was, in fact, structural. Its form was shaped to challenge the technology of the time and redirect the consumer housing industry away from frame construction toward alternative formal practices. MHOF was created to symbolize the freedom “plasticity” might one day provide the building industry, but in the end its structural integrity proved to resist the rhetoric of its fantasy form. Monsanto played an historic role in marketing the desire for “plasticity” and the promise of tension-shell construction in the 1950s, but despite its better efforts, was never able to overcome plastics’ own “innate” limitations.

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[107] Albert G. H. Dietz, “Is a Plastics Breakthrough in Building Due in the Sixties?” *Architectural and Engineering News* 2 (July 1960): 4.

FIG. 1
DORON PLASTIC ARMOR SUITS.
MONSANTO MAGAZINE, 1945

FIG. 2

GLASS REINFORCED PLASTIC RADOMES, INSTALLATION.
MONSANTO MAGAZINE, JULY 1954.

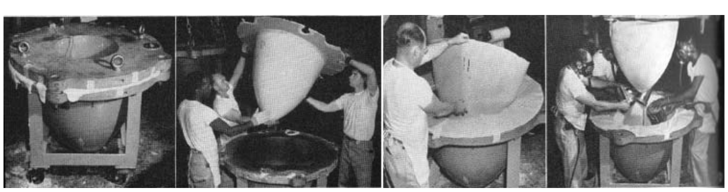

FIG. 3

GLASS REINFORCED PLASTIC RADOMES, MANUFACTURE.
MONSANTO MAGAZINE, JULY 1954.

The finished product. Langley's all-molded plywood ship passed preliminary tests last year. Designed as a "family plane," it may become a bomber trainer.

FIG. 4
"PICTURES OF AIRCRAFT FACTORIES USUALLY SHOW A MORASS OF TOOLS AND JIGS AND RIVET GUNS. IN THE PICTURE ABOVE, HOWEVER, THE WORKMEN ARE BUILDING A WING—A WING FORMED SOLELY OF WOOD STRIPS AND RESIN."
"PLYWOOD FLIES AND FIGHTS,"
FORTUNE MAGAZINE, 1942.

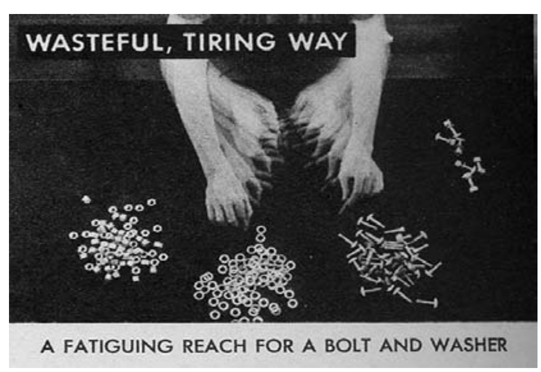

FIG. 5
TIME-MOTION STUDIES OF WORKER'S FATIGUE. *FORTUNE MAGAZINE*, 1942

FIG. 6
POST WAR ADVERTISEMENT. *LIFE,* 1946.

FIG. 7
DAMP CLOTH CONSUMERISM. "PLASTICS...A WAY TO A BETTER MORE CAREFREE LIFE," *HOUSE BEAUTIFUL*, OCTOBER 1947.

Fig. 8

"From finger tips to wing tips." *Monsanto Magazine*, 1946.

Fig. 9

"Back Yard Beach," a "Do-It-Yourself" Plastic Swimming Pool.
Monsanto Magazine, August 1955.

Fig. 10

car body built at the Glasspar Company in Costa Mesa, California.
Monsanto Magazine, April 1953.

Fig. 11

"La Chaise" By Ray Eames and "Tulip" Chair By Eero Saarinen

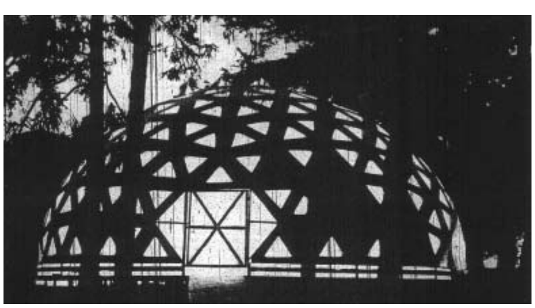

Fig. 12

Buckminster Fuller, Plastic Dome

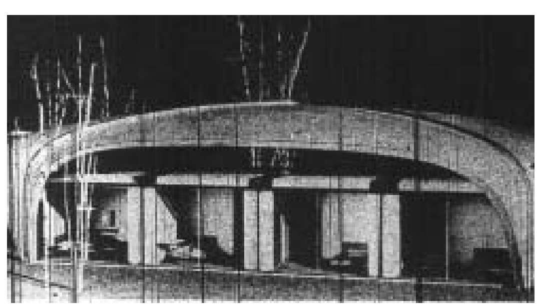

Fig. 13

Eliot Noye, Plastic "Dream House"

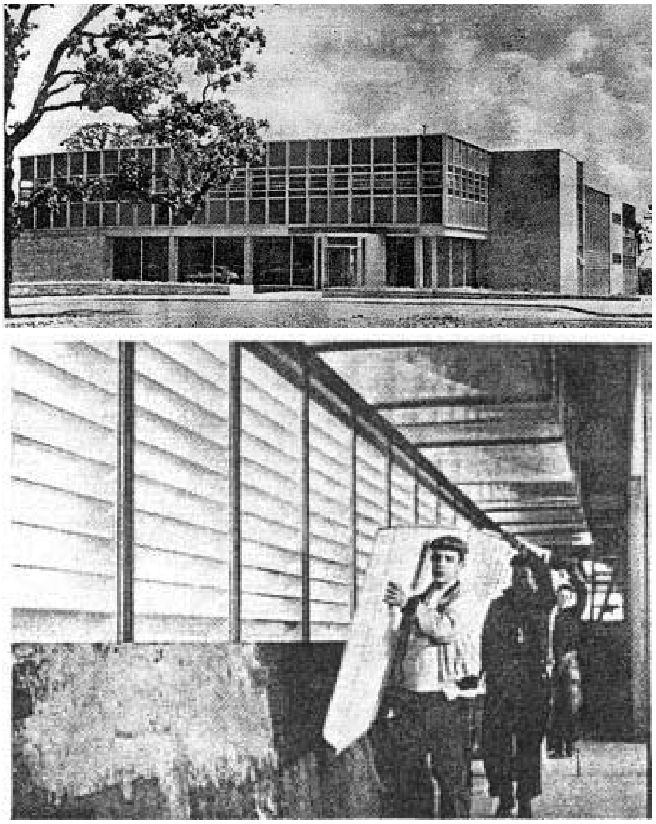

Fig. 14

Monsanto Plastic Office Building, Creve Coure Campus. *Progressive Architecture*, 1957.

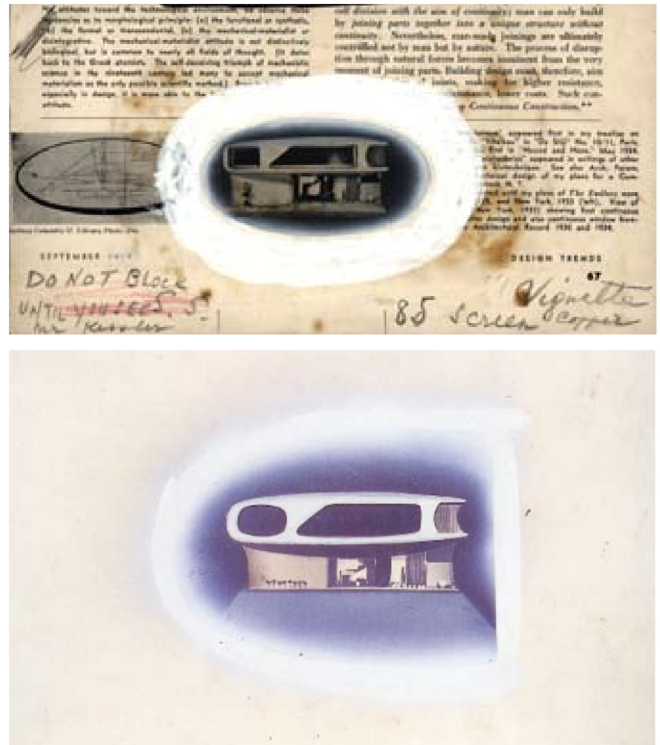

Fig. 15

Collage Drawings over Original Images of Space House (1933) and Endless Theater (1924-1926), 1939.
Courtesy Austrian Frederick and Lillian Kiesler Private Foundation, Vienna

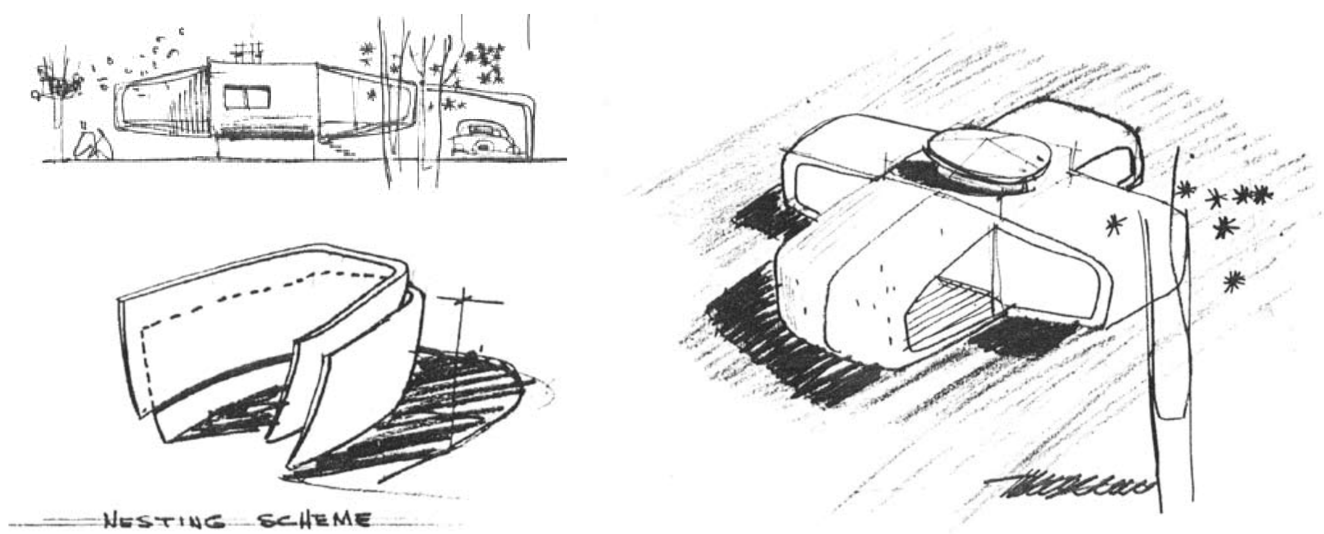

Fig. 16

Monsanto House of the Future, Design Sketches of Continuous "U" Bents: Elevation, Axonometric, and Shipping Scheme.
Courtesy Massachusetts Institute of Technology
Department of Architecture.

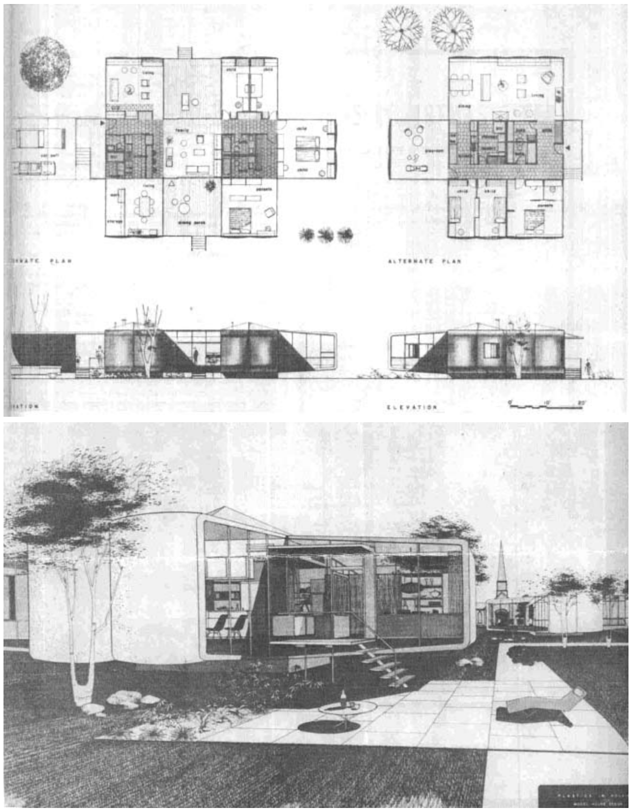

Fig. 17
MHOF, Perspective and Site Plan, 1954.
Courtesy Monsanto Company.

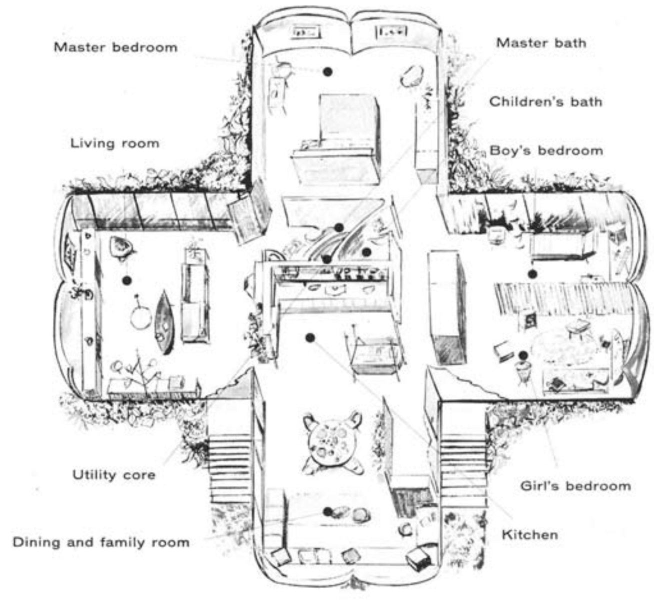

Fig. 18
MHOF, Axonometric Floor Plan.
Monsanto Magazine, Summer 1957.

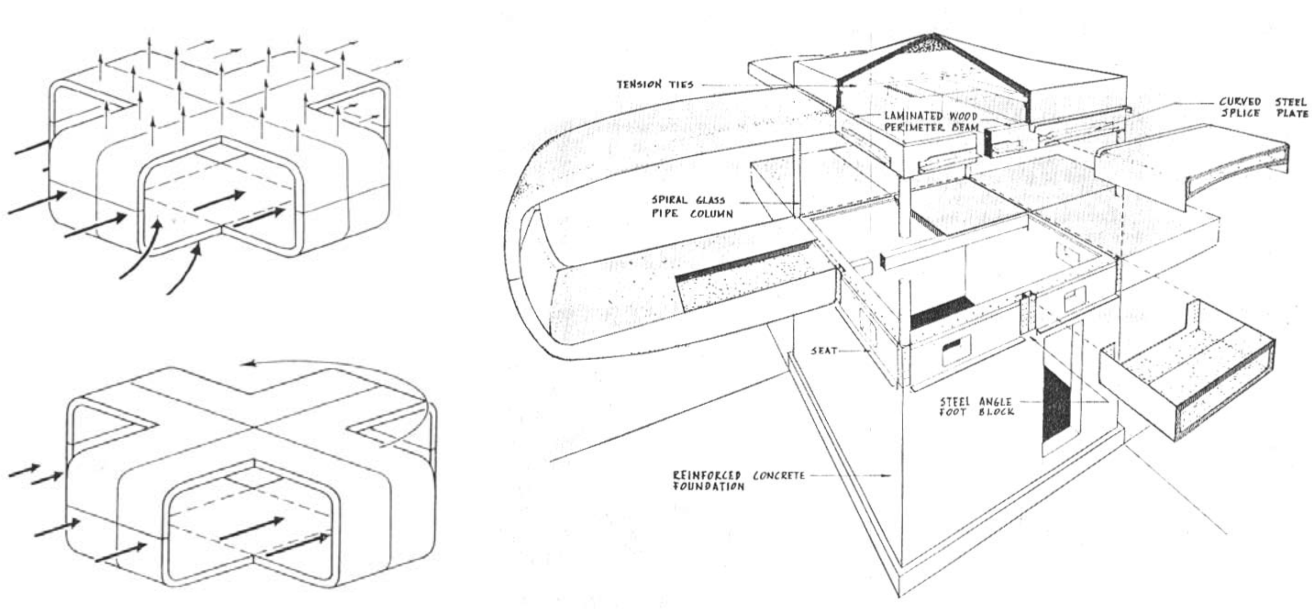

Fig. 19
MHOF, Diagrams of Structural Loads and Box Construction.
Modern Plastics, 1957

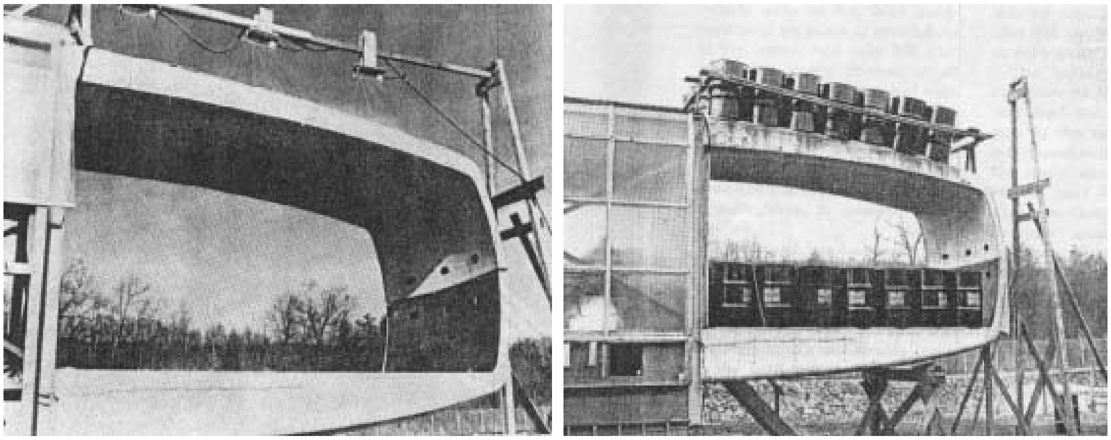

Fig. 20
MHOF, Load and Temperature Testing of Bents. *Modern Plastics*, 1957.

Fig. 21
MHOF Model Images, Exhibiting Plastic "Kit of Parts." *Monsanto Magazine*, August 1956.

Fig. 22
Design Sketch of Tommorrowland, Disneyland, Anaheim, California.

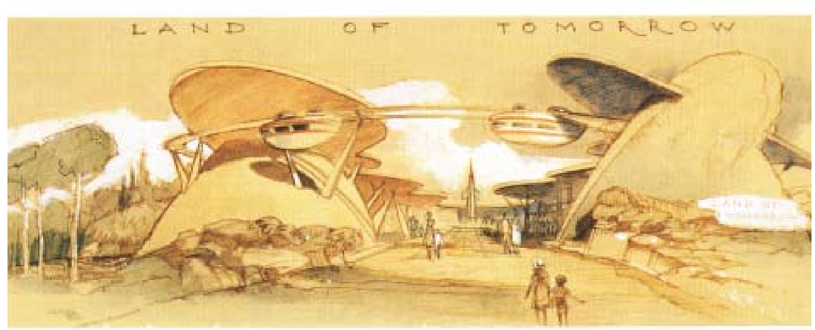

Fig. 23
Design Sketch of Tommorrowland Gateway, Disneyland, Anaheim, California.

Fig. 24
MHOF Construction at Disneyland, 1957.
Courtesy Monsanto Company.

Fig. 25
MHOF at Disneyland. *Monsanto Magazine*, 1957.

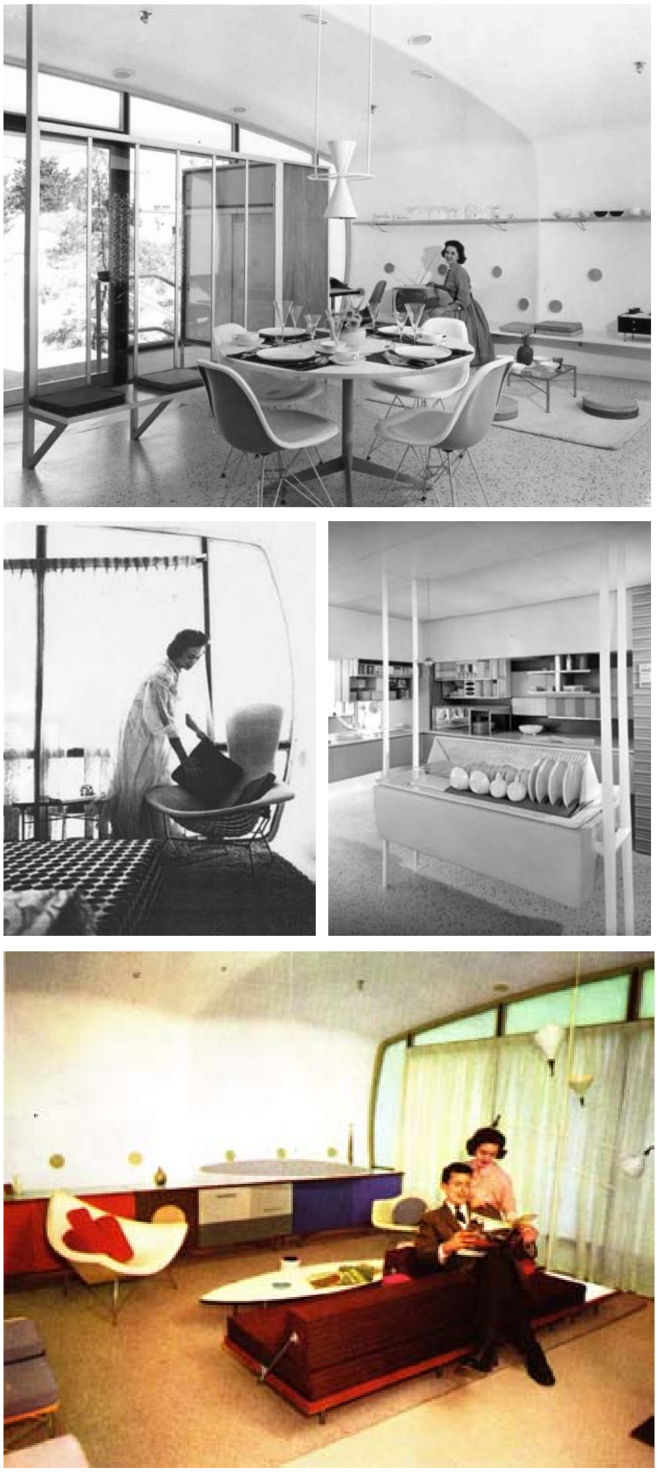

Fig. 26

MHOF, Interior Images: Dining, Living, Kitchen, and Master Bedroom, 1957. Courtesy Monsanto Company.

Fig. 27

MHOF at Disneyland, 1957. Courtesy Monsanto Company.

Fig. 28

MHOF, Demolition, *Monsanto Magazine*, March 1968