HIGH SCHOOL EDITION
Journal of Student Research
Volume 12 Issue 1 (2023)

The Dymaxion Dwelling Machine: R. Buckminster Fuller's Vision to House All of Humanity

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ABSTRACT

Traditional housing is, and has for many centuries, been uniquely made for their individual clients, making houses difficult to mass-produce and, sometimes, too expensive to provide for those who need it most. R. Buckminster Fuller, an architect who believed that we had an obligation to provide adequate housing, attempted to address this challenge almost a century ago through his creation, the *Dymaxion Dwelling Machine*. The *Dymaxion* (a portmanteau of Fuller's favorite words: dynamic, maximum, and tension) *Dwelling Machine* was a dome-shaped home optimized for mass-production, and it maintained a higher rate of efficiency and sustainability than the standard cube-shaped home. This paper will analyze several methods and facets that Fuller implemented within this atypical house, such as the *Dymaxion Bathroom*, *Fog Gun*, tensegrity, cooling/heating, autonomy, affordability, materials, maintenance, and construction, that inspired sustainable, versatile, and affordable solutions that have contributed to addressing the climate and inadequate housing crises of today.

"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

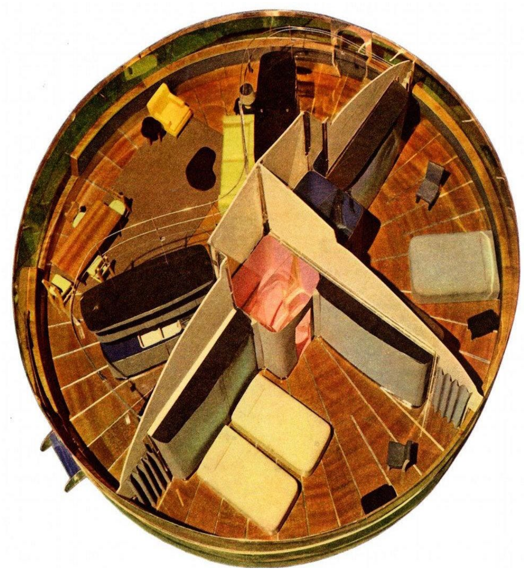
Introduction

Nearly a century ago, architect and inventor, R. Buckminster Fuller, introduced a more sustainable, adaptable, and affordable housing alternative for all of humanity [2]. In 1922, Fuller's 3-year-old daughter, Alexandra, died due to complications from polio and spinal meningitis. Inadequate housing was speculated to have been the cause [2]. Fuller, thenceforth, devoted part of his career to producing a secure and affordable housing alternative so no one else would suffer from the same fate, and, thus, the *Dymaxion Dwelling Machine* was born. This dome-shaped home would soon serve as Fuller's vision towards providing a more efficient, and, consequently, more sustainable high-standard of living to one-hundred percent of humanity [4].

Context

Dymaxion (Wichita) Dwelling Machine

The *Dymaxion* (*Wichita*) *Dwelling Machine*, conceived by R. Buckminster Fuller in 1927 and later first prototyped from 1944-1946, exceeded the capabilities of a conventional house. The 100 square-meter, 36-foot diameter modular hemisphere design was more sustainable, versatile, affordable, and efficient than the common building practices of his time and today [2]. Fuller designed the *Dwelling Machine* based off of his slogan, "doing more with less," and though the building may seem simple on the outside, everything about the structure was built to minimize cost while maximizing efficiency [2].



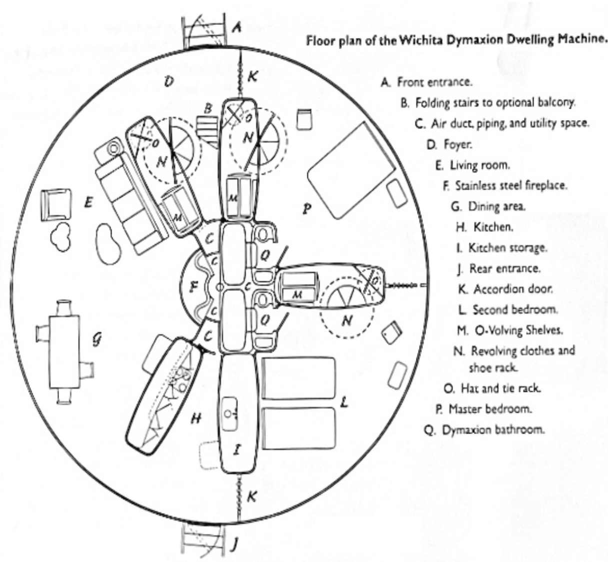


Figure 1. Modeled interior of *Dwelling Machine* (Source: messynessychic.com website)

Figure 2. Labeled interior of *Dwelling Machine* (Source: Baldwin 51)

Sustainability

Sustainability, a small but important aspect of the *Dymaxion* (*Wichita*) *Dwelling Machine*, was accomplished through the build's use of recyclable and reusable aluminum and water-collection systems combined with water-conservative appliances [10]. Additionally, the structure was cooled, heated, and powered through natural means [2].

Dymaxion Bathroom

One of the most notable features within the *Dymaxion Dwelling Machine* were the two *Dymaxion Bathrooms* it possessed. The *Dymaxion Bathroom*, an invention Fuller patented in 1940, was an all-in-one bathroom alternative designed to vastly decrease the amount of water regularly 'wasted' in the conventional bathroom while functioning more efficiently [2]. The 5-by-5-foot lightweight 250-pound (113.4 kg), prefabricated bathroom, consisting of four rust proof sheet metal stampings or plastic moldings, was to provide a fully functional sink, ("allegedly waterless" [2].) Packaging Toilet, water-conservative shower, integrated lighting, ventilation, and plumbing [2]. The sink, shower, and tub was to be already pre-plumbed and, though never produced, the toilet would seal excrements into a plastic bag which would then be used as compost or fuel in the form of methane gas while urine was disposed of separately [2]. This process was intended to be sanitary, odorless, and eliminate the need for water or a toilet lid [2].

The entire bathroom's installation could have been accomplished with only two people [2]. All corners and edges in the bathroom had 5-cm radii to allow for easy swabbing and cleaning. Additionally, electric heating strips were installed within the walls to keep the bathroom warm and dry [2]. An opening below the sink would draw out any steam or unpleasant fumes and a floor drain prevented any chance of flooding [2].

Fuller's goal was to minimize the cost, components, and most importantly, the amount of water bathrooms consumed through means of mass-production; however, setbacks prompted by plumbers fearing their jobs halted production [12]. Several aspects of the *Dymaxion Bathroom* can now be seen in bathrooms found in today's airplanes and trains [5].

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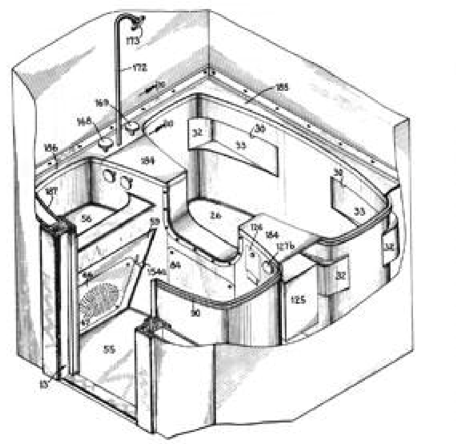


Figure 3. Patent design of the *Dymaxion Bathroom* (Source: patents.google.com website)

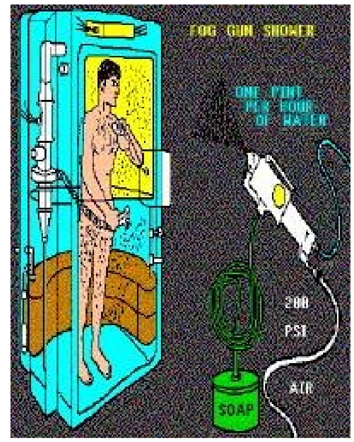


Figure 4. Illustration of the *Fog Gun* (Source: weirduniverse.net website)

Fog Gun

A particularly interesting facet of the *Dymaxion Bathroom* was the *Fog Gun* which Fuller invented in the 1920s [5]. When working on a naval ship, Fuller discovered that, even when his hands were covered in grease and oil, the wind-driven ocean fog, alone, would thoroughly cleanse him [5]. Fuller then tried inventing a device that could replicate this phenomena, and, ergo, the *Fog Gun* was born. It was theorized that the *Fog Gun* would use a combination of atomized water particles and compressed air to cleanse people at 200 psi (pounds per square inch) [10]. If it functioned accordingly, a one hour shower would only require around a pint of water [10]. Additionally, not only could the *Fog Gun* have been used on people, but dishes and laundry as well [5].

Cistern

Though not the first to employ a cistern within a home, this proved an efficient method for collecting and recycling water for later use [13]. Water would fall through gaps in the roof and enter a system of Neoprene gutters which traversed into pipes within the *Dwelling Machine's* domical roof and then into a tank, making recycling possible [13]. Additionally, a fiberglass-Neoprene tent that lined the interior of the *Dwelling Machine* would collect any moisture or condensation inside the dome and direct it towards the same water tank; this process also helped reduce humidity within the dome during non-rainy weather [13]. These methods of collecting water combined with water-conservative appliances allowed for minimal water wastage [13].

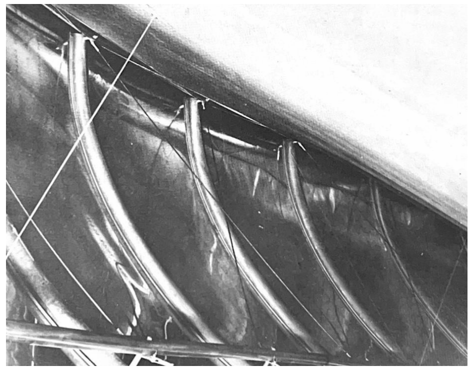


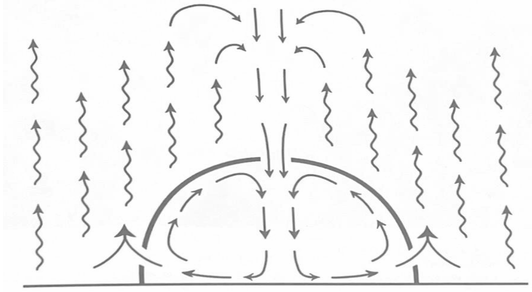
Figure 5. "Hat-sectioned" ribs which acted as roof support and gutters (Source: Marks 135)

Natural Cooling and Ventilation

In 1940, Fuller stumbled upon a counterintuitive discovery when inspecting the *Dymaxion Deployment Unit* (DDU), a predecessor of the *Dymaxion Dwelling Machine* and a cheap method of housing soldiers during World War II [2]. This discovery would give birth to what Fuller called, the "Chilling Machine" [2]. Fuller discovered that the *Deployment Unit's* interior remained in a passively-cooled state, whilst its exterior could literally fry an egg [2].

Tests found the source of this unexpected phenomena [1]: while the Kansas summer heat scorched the *Deployment Unit's* exterior, the shell's exterior heat rose and lowered the pressure at the base of the dome and, consequently, created a suction-effect near the bottom which would draw out the interior's air, lowering the dome's interior pressure [1]. Afterwards, due to heat's low density and the interior's lowered pressure, hot air would enter through a small hole located at the top of the *Deployment Unit's* mast and compress and cool due to the Bernoulli Effect, which states that large volumes of air are cooled when going through a small opening [1]. A version of the *Dymaxion Deployment Unit's* 'chilling effect', as shown in Figure 6, would later be implemented within the *Dwelling Machine* to provide passive cooling [2].

Not only did the *Dwelling Machine's* hollow rudder-vent contribute towards ventilation and cooling, it prevented unwanted heat loss by rotating and, thus, maximized the aerodynamics of the dome as well as vacuumed out any stale, interior air [2]. Through wind-tunnel tests, compared to a normal cubed house, a hemisphere was found to have a drag advantage of ten-to-one, with heat loss directly correlated to drag [5]. Additionally, the 62.5-ton-resistant deck used 10-pound (4.5 kg) sheet stampings which served as air ducts and heat exchangers [5]. Weatherstripping covering the window and door cracks inside the dome was also found to provide insulation almost as favorable as an 8-inch cork wall [5]. The *Dwelling Machine* also employed downdraft ventilation to draw dust to the baseboards and through filters which eliminated the need for dusting and vacuuming [11].



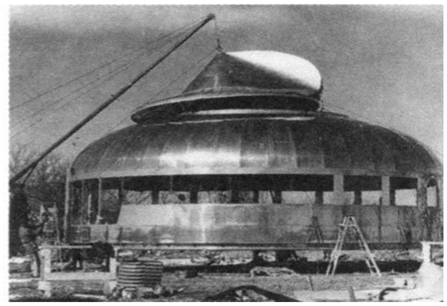


Figure 6. "Chilling Machine" effect in action (Source: Baldwin 115)

Figure 7. Ventilator being placed on top of the *Dwelling Machine* (Source: e2dymaxionhouse.wordpress.com website)

Autonomy

Another important aspect that Fuller wanted the *Dymaxion Dwelling Machine* to possess was for it to be autonomous [2]. Autonomy would allow more flexibility for the dome; for instance, it would no longer have to rely on external sources for water, electricity, or ventilation – it was provided naturally [2]. Its self-sufficiency and versatility would reduce the dome's carbon footprint, maintenance costs, and allow domes to be transported to remote and impoverished areas [2].

Affordability

One of the most important aspects of the *Dwelling Machine* was its affordability and ability to be mass-produced [2]. Similar to a Ford Motor car at the time, the *Dymaxion Dwelling Machine* was to be obtainable by everyone [3]. In the end, the dome, itself, its shipping, and its erection was meant to be cost-efficient [2].

Versatility

An aspect of the *Dwelling Machine* which made it versatile, besides the fact that it was autonomous, was its aptness to any upgrades and its need for infrequent repairs. The appliances and utilities could be replaced with ease because the dome was divided into several main categories of the shell, structure, and installations [11]. This meant individual parts could be removed without impacting any other features [11]. The *Dwelling Machine* also had a great advantage, compared to normal houses, on uneven or environmentally sensitive sites since the only earthmoving necessary was to auger the post hole [10].

Tension, not Compression

Due to his vast knowledge in geometric shapes and tensile structures, Buckminster Fuller designed the *Dwelling Machine* to rely on tension instead of the standard compression approach [10]. The benefits of prioritizing tension instead of compression made the dome lightweight, use less materials, and cost less to ship. Less materials used in construction meant less money spent on the dome and quicker erection. The central mast of the *Dwelling Machine* utilized the properties of tension suspension to fix the surrounding aluminum shell sturdily in place [10]. The mast, made of seven 3-inch tubes of stainless steel, mounted on a sunken concrete post and bore the dome's entire foundation [10]. Additionally, a high-carbon tension spoke formation consisting of a net of radiating high-tension cables rested on the masthead, as shown in Figure 9, creating a structure cage which suspended the dome's shell due to the nature of tensegrity [10].

Interconnected to the spokes A-, B-, and C-rings, which were the circular rims of the horizontal, wire-wheel complex, held the dome's aluminum exterior in place [10]. B-rings, formed by tubular sections of stainless steel, sustained the heaviest compression thrust of the three [10]. Elevated above, but anchored by tensile wires to the ground, the structure rested on a foundation plate, held steadily by the mast, above ground level [11]. Finally, steadied by X braces to the 12 anchors around the deck rim, the dome became virtually earthquake-proof and hurricane-proof [10].

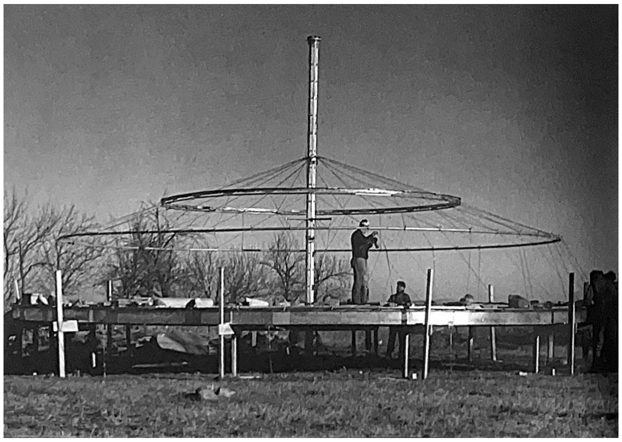


Figure 8. Structural frame of *Dwelling Machine* (Source: Fuller 240)

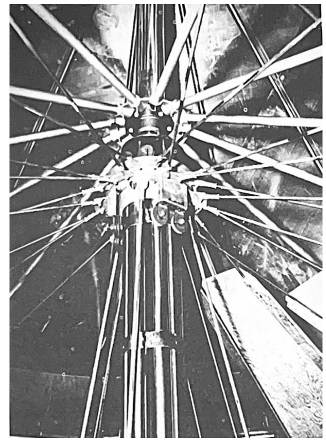


Figure 9. Masthead spoke radiating tension cables (Source: Marks 137)

Materials and Maintenance

The *Dwelling Machine* consisted of permanent materials requiring no maintenance [11]. There was nothing to paint, rot, and the hemisphere-shaped roofing would never have to be replaced [11]. Due to the surplus of aluminum created by the Beech Aircraft company at the end of World War II, most of the structure, specifically the walls and roof, were fabricated almost entirely out of corrosion-resistant aircraft industry aluminum alloys while the windows were made out of plexiglass and the roof ventilator was made out of aerodynamic sheet metal [11]; the build also incorporated wood and synthetic rubber [12]. Since the aluminum parts had a 4 percent copper content that made it more durable, the material was more prone to corrosion [8]. To address this issue, most of the metal components within the *Dwelling Machine* were layered with pure aluminum to decrease corrosion susceptibility [8]. Besides being recyclable and reusable, aluminum was non-oxidizing, light, durable, and easily manipulated, allowing it to be curved and bent readily [11]. The alloy's chemical properties also allowed for adequate cooling and ventilation.

Although there were some downsides to employing aluminum, such as its lack of stiffness in relation to iron or steel, its performance outweighed this in Fuller's eyes [11]. Nevertheless, the *Dwelling Machine's* mast was made of stainless steel instead [11]. The floor was made of plywood and natural cork, making the deck impermeable to gas or liquids, resistant to mold, and fire-resistant [11]. In total, the structure had approximately 2000 parts with many systems that firmly fit together without glue or nails, such as deck flooring [11].

Safety

In addition to all of the materials within the *Dwelling Machine* being non-toxic and indefinite, the dome was designed to resist earthquakes, hurricanes, storms, and tornados [5]. For example, in 1964, a tornado passed by only 300 yards (274 meters) away and the house did not sustain any damage [5]. This was because the *Dwelling Machine's* ventilator was designed to equalize the internal and external pressure which would then allow the dome to resist a total lifting force of 72 tons [5]. The shape of the dome and its suspension system made it virtually earthquake proof as well [11].

Shipping

The *Dymaxion Dwelling Machine*'s unique characteristics, such as its lightweight and autonomous properties, vastly contributed to low shipping costs [5]. For example, each component of the dome, weighing no more than 10 pounds (4.5 kg), could be shipped in a reusable stainless steel 16-by-4.5-foot cylinder which could be transported anywhere by truck [11]. Additionally, since the *Dwelling Machine* relied on a combination of sturdier materials and the natural laws of tensegrity rather than using more materials, the overall weight was drastically decreased to only 3 tons, compared to the average 150-ton contemporary house, allowing for cost-efficient transportation. The dome had a 118-foot plexiglass window and was held down by 12 anchors that could resist an upward pull of 6 tons [13]. The 22-foot mast weighed 72 pounds (32.7 kg) and all materials in the *Dwelling Machine* were non-oxidizing, making them invulnerable to rust [13].

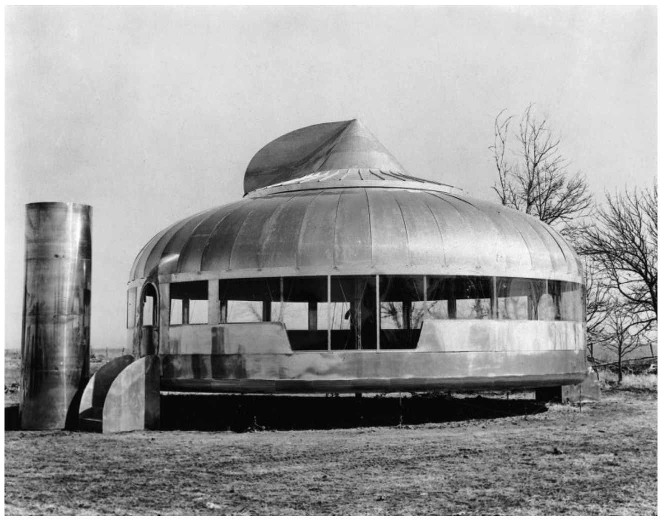


Figure 10. 16 x 4.5 ft cylindrical aluminum shipping container (left) and fully built *Dwelling Machine* prototype (right) (Source: blogs.uoregon.edu website)

Mass-Production

Though only a singular prototype of the *Dwelling Machine* was produced, Fuller envisioned mass-producing this autonomous dome across the globe [2]. The lightweight properties, few parts needed in construction, and cheap, but durable, materials promoted this idea [2]. Mass-production of the dome, as well as its other appliances such as the Dymaxion bathroom, would cost little and require no maintenance due to the installations' simplicity. The average dome cost around $6,500 while it could have been soft-tool manufactured for only $1,800 each [13]. Due to its inexpensiveness, like an automobile, it could have been paid off in 5 years [2]. It was estimated that 10 million dollars would have sufficed to manufacture 20,000-units per-year back then [10].

Figure 11. Model of planned *Dwelling Machine* community (Source: messynessychic.com website)

Quick Erection or Construction

The erection of the dome was designed to be quick and efficient, only taking mere days. Everything along with all necessary appliances such as a kitchen, bathroom, and other necessities were either pre-installed, pre-built, or easy to assemble along with the dome [10]. After being unpacked, the 16 inexperienced workers erected the *Dwelling Machine* prototype in just 2 days during cold and windy conditions [2]. There was minimal foundation work, and no long-term costly construction loan was required [2]. Additionally, the dome could easily be disassembled and moved to a new location if needed [2].

Conclusion

R. Buckminster Fuller's *Dymaxion Dwelling Machine* was documentation that sustainable, adaptable, and affordable housing for all of humanity could have been and can be achieved. Nearly a century later, today, homelessness is deemed an even greater problem than before, creating a greater need for a viable solution. Supported by the latest innovations, technology, and international governments, we can build upon the ideas presented in the *Dwelling Machine* to provide a framework to address the global housing need without depleting the natural resources of this planet.

According to Fuller, nothing ever changes until a new method or model replaces an existing, obsolete one. The *Dymaxion Dwelling Machine* is such a model.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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