Dymaxion Dwelling Machine

by Jay Baldwin

Imagine if cars were built in the same way as houses. When you placed your order, squads of workers would appear in your driveway, piling the materials and setting up the tools of their unrelated trades. Panel beaters would noisily form sheet-metal shapes that flashing welders would join into the body shell. A portable foundry would deliver castings and forgings to the machinists' lathes and gear cutters. Tire- and glassmakers would tend their furnaces and moulds, upholsterers their cutting and sewing tables. All would be exposed to weather, vandals and thieves.

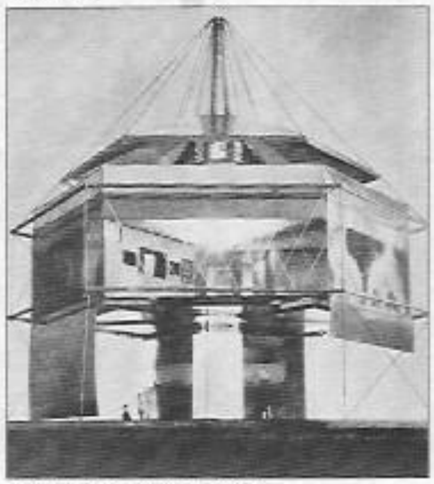
About six months later, the painters would apply the final polish and hand you the keys. The contractor would hand you the bill — not for $15,000, the average price paid for a family car these days, but for $225,000, the price for a hand-made, low-production car of the Ferrari ilk. A completely custom, one-of-a-kind machine might cost millions.

If you financed your driveway-built car in the same way as you do your house, the above costs would be tripled by the usurious-but-legal 200 percent mortgage interest rates now in effect. (With a 30-year mortgage, you actually pay about $340,000 for a house on which you borrow $100,000.) Unless you are a speculator, it seems safe to say that the foregoing procedure is not an intelligent way to deliver consumer goods of any sort. It is no wonder that decent low-cost housing does not exist yet.

Now imagine, however uneasily, that houses were produced and financed in the same way as cars. To most people, the very thought of an industrially mass-produced home is emotionally repellent, implying unaesthetic institutional conformity at best. The concept of reasonably priced, appealing housing seems to be an unattainable abstraction, and burdensome mortgage payments a fact of life. But to Buckminster Fuller, mass productions held the promise of worldwide affordable shelter built to very high standards.

Construction was, and still is, the only major industry to remain a fragmented, handicraft effort even in the world's industrially advanced nations. "Craft-and-Graft," Fuller called it. Methods, materials and designs had not changed for centuries. The business of building had become conceptually fossilized, buried in an antiquated system of building codes, suppliers, financial institutions and other vested interests. Architects serving those interests merely shuffled a limited selection of components into superficially new styles. These were dutifully reported by the media, shaping and reinforcing public preference for a remarkably narrow definition of "traditional." The move toward modern architecture, which was just beginning at that time, continued the longstanding disregard for efficient use of materials and energy — matters of critical importance to Fuller.

Because of their inattention to basic efficiency, Fuller did not expect much from architects or from the schools that trained them. He often exasperatedly referred to both as "exterior decorators." The American Institute of Architects countered in 1928 with a resolution: "Be it resolved that the American Institute of Architects establish itself on record as inherently opposed to any peas-in-a-pod-like reproducible designs." At least their position was clear.



RBF's 4D House Model, 1927

Without the leadership of architects and universities, building contractors had little motivation to invest in new concepts, even if their decentralized industry could have afforded to do so. The equally localized manufacturers of building supplies faced similar constraints, as Fuller himself had discovered with his short-lived block business. It was clear that innovation would have to come from individuals — people who did not have to worry about earning a living. In 1927, Buckminster Fuller went to work.

He started by considering the problem to be worldwide, because it was (and still is). Then, as now, the health of more than half of humanity suffered from the effects of inadequate shelter. If he was to serve all humanity, he would have to take maximum advantage of the economies of mass production by making the potential market as large as possible.

Worldwide distribution meant the proposed housing would have to be compact and light enough to ship anywhere that local housing methods were not effective. (Fuller recognized that building with local materials could be the best solution; he did designs in bamboo and thatch, for instance. But he insisted that any material should be used efficiently.) He thus assumed air shipping — even of completely assembled 10-story apartment buildings, which he designed to be slung horizontally under zeppelins. Fuller was unwilling to restrict his designs to those which would have to be shipped by rail and over highway bridges, a requirement that still forces debilitating compromises on conventional factory-built units. Fuller's designs called for relatively small parts that nested tightly for economical shipping and handling.

As for weight, Fuller noted that a conventional house totals about 150 tons, yet it is not particularly sturdy or long lived. Furthermore, that weight must be handled and shipped repeatedly in the construction process, often by large, expensive machines needing substantial roads and bridges.

Fuller's experience in the United States Navy taught him that performance per pound of materials could be high if the materials were used in a way to take best advantage of their inherent strength. That meant using tension whenever possible. Most conventional construction is literally a pile of materials held together by friction and gravity. Tension structures, typified by suspension bridges, bicycle wheels and sailboats, tend to be light, airy, elegant and a trifle flexible. They handle loads through intelligent design rather than by brute force.

A natural consequence of lightweight and compact size is that a minimum quantity of material is used — true dematerialization in the Zen sense. Fuller declared this strategy to be a basic design principle. He called it "more-with-lessing" in his lectures and books. In private, he used the wonderful metaphysical term "ephemeralization." Way back in 1927, he saw that the world's resources, including know-how, had to be fairly distributed, or redistributed, if all humanity were to be taken care of and resource wars were to be averted. Conservation and just utilization of resources also reduce environmental problems. The mandate was clear: Use less stuff, and use it wisely.

Fuller's first design appeared in 1927 and was called the 4D House, referring to Einstein's then new fourth-dimension theories. A Chicago adman who thought 4D sounded like an apartment number coined the word Dymaxion (from dynamism, maximum and tension), which Fuller adopted. The 4D Dymaxion House structurally resembled three 50-foot diameter hexagonal bicycle wheels laid on their sides, hanging from a central mast. It was steadied by a tensioned network of triangulating cables. Calculations showed that, complete with furnishings, it would weigh 6,000 pounds, about the same as a large automobile. No single part would weigh more than one person could lift and install unassisted. The house could be erected and ready for occupancy in one day.

Fuller saw no reason why the Dymaxion House could not cost the same per pound as a large car if it were produced in quantities of 5,000 per day, typical of a factory making a popular car. (The largest house builders fabricate that number in a year.) As with cars, there could be cosmetic styling differences, but not conceptual differences, between models.

The first Dymaxion House existed only as an elaborate scale model and was even more radical than its futuristic appearance suggested because it was part of a system that included all utilities, supplies, household functions and even transportation. One room was dedicated to the control of the house's many automated features, in much the same spirit as the highly touted "smart houses" of today. The room also held a learning center featuring a telephone, worldwide shortwave radio set, television (not practical then, but Fuller saw the development of television as inevitable), calculator (also not yet developed), duplicating machine (remember them?), library and world maps.

The central mast not only supported the house, it contained the mechanical core — plumbing, heating and cooling, water, electrical and waste handling equipment. Movable partitions plugged

The central tension mast for the Wichita House was built with long, "closest packed" aluminum rods.

into the mast to service the built-in appliances they contained. Because they could fit into the mast anywhere, the partitions were easily rearranged by occupants, giving a variety of layouts and room sizes.

The appliances contained in the partitions were designed to reduce chores to a minimum: the washing machine, rare in those days of cheap domestic help, also dried, folded and put away the laundry. Fan-driven air systems forced dust and fumes toward the floor and out through baseboard vents. Newly developed electric eyes ordered pneumatically operated doors to open as a person approached with hands full. Closets were giant lazy Susans, an idea that is just now gaining popularity in posh homes.

The appliance partitions were easily removable from the house as units, allowing their replacement with more efficient devices as technology improved. The Dymaxion House thus avoided obsolescence both as a structure and as an investment. Fuller noted that one reason for the severity of the 1929 crash was that banks foreclosed on obsolete houses — most houses did not have indoor plumbing then. (Could that happen again with today's energy-pig nonsolar houses?) A Dymaxion House would hold value, or even increase it, when energy became expensive.

Dymaxion Houses could also avoid demographic obsolescence and undesirable neighborhood changes by being moved — they could be dismantled as easily as they had been erected, leaving only a simple mast base. To make this reasonable and to reduce initial costs, the Dymaxion House was to be autonomous, needing no connection to an enormously expensive and politically sensitive network of umbilical piping, wiring and roads. (Everyone knows what happens to land prices once utilities and roads are in place.) There was provision for water capture and storage, grey-water recycling and purification. Water use was minimized by a "fog gun" shower that needed only a pint per use. Most of the cleaning was done by a pleasant blast of hot air driving the water vapour. (Currently available versions use unheated air and are, at least to my skin, dreadful.)

The toilet packaged human waste for pickup by chemical- and agricultural-supply firms. (Did you know that a year's worth of one person's excrement, if dried, amounts to only a cubic foot or so?) Electricity was to be generated by built-in wind turbines or high-efficiency motor-generator sets that would also use the exhaust and radiator heat to warm and cool the house (we call them "cogen" sets today). Heating and cooling were to be mostly by solar means. Insulation, vacuum-sealed double-paned windows and the minimum surface of the rounded shape reduced the demand for power. The Dymaxion House was easily adaptable to any climate.

What little fuel and water a Dymaxion House needed was to be supplied by a service industry that was an essential part of the Dymaxion scheme. In fact, Fuller proposed a Global Dwelling Service that would operate as a utility. In much the same way Bell telephone rented communications hardware, the firm would rent and support the houses, including the system hardware downtown, a service no ordinary family could afford to buy. Rental equipment would have to be of good quality to reduce service costs and to ensure system reliability. (The quality of retail goods tends to be as low as the market will tolerate.) When true obsolescence occurs, rented hardware is replaced, just as Ma Bell replaced the "number-please" telephones with dials and then buttons.

To those who objected to the idea of renting a house, Fuller retorted that unless your mortgage is paid off, you are a renter — of money. It seems indisputable that a Global Dwelling Service could bring good-quality housing within the financial reach of a significant portion of the world's population. Fuller, however, was unable to secure financial backing for the tooling costs of the Dymaxion House, not surprising with the onset of the Depression.

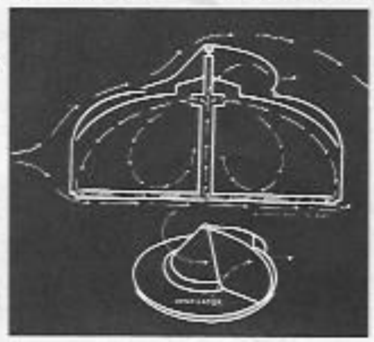
The downdraft ventilation system, rotating closet and "ovolving shelves" were characteristic of Bucky's Dymaxion approach to building a dwelling "machine," not merely a prefabricated house.

A disappointed Fuller forged ahead in 1936 with the Dymaxion Bathroom, intended to make obsolete expensive and hard-to-clean craft-built designs. It consisted of four die-stamped pieces totalling about 400 pounds. All plumbing, wiring, heating and ventilation (downdraft to pull fumes and steamy air to the floor) were built in at the factory. There were many practical features, such as a sink made splashless by having the spout in the near rim facing away from the user — no more water up the sleeves. Perhaps the best feature of the bathroom was its crevice-free, wide-radius construction that made thorough, hygienic cleaning a trivial task.

A dozen prototype Dymaxion Bathrooms were constructed. They worked fine (several are still in use), but the project was discontinued. The manufacturer blamed trade-union resistance; the unions blamed gutless management. The bathroom joined the ranks of the never-produced, though there is a trend toward the basic idea today.

World War II brought an acute need for cheap, easily deployed military housing. Fuller responded with the Dymaxion Deployment Unit, derived from a standard Butler grain bin. While lacking charm (to put it charitably), the units proved to be surprisingly comfortable. Several hundred were made before a steel shortage curtailed production. The most important aspect of this project was the discovery that the unit would air-condition itself — even if uninsulated — without fans, evaporators or any other mechanism. Even when the bare steel shell was hot enough to fry an egg, the interior space would stay about 15 percent cooler than the outside ambient air temperature.

The discovery of this chilling effect inspired Fuller to seek out what nature wanted to do and then help it along. In this case, totally against intuition, the interior hot air went down and out around



the base, pulling in cool air through the center roof vent. Amazingly, the chilling principle remains unexploited today, despite ample proof that it works well. Perhaps it is because the effect works only in dome-shaped buildings. So far. Another advantage of domelike structures is that heat does not stratify inside; the temperature near the top is about the same as at the floor.

The next step was a full-size prototype house, which Fuller named the Dymaxion Dwelling Matching and the public called Wichita House. Fuller knew that the end of World War II would bring both large-scale unemployment for aircraft workers and a severe need for new housing. The Dymaxion Dwelling Machine was to be made from aircraft materials on Beech Aircraft's B29 bomber assembly line in Wichita, Kansas.

The design went much further than the original 4D Dymaxion did in reducing repetitive household chores and maintenance. Fuller considered grunt work to be a demeaning and inappropriate use of time for humans better occupied with intellectual, artistic or recreational pursuits. In 1945, most people did not worry too much about such things, but Fuller thought they should.

He wanted to liberate people like my mother, who was not alone in defining a "well-kept house" as one that looked as though nobody lived there. If she was sewing (bless her), she would snatch up her work and hide it before answering the doorbell. Her gracious home looked like many you see in magazines. Like them, it required a housekeeper, either her, a "cleaning lady" or a reluctant draftee from the family.

These days, a large percentage of households are single-parent, senior citizen or two-worker. Most people's idea of a traditional and desirable home is not in tune with this reality. For many of us absentee tenants, it has become a toss-up between hours of drudgery, spending lots of money on hired hands or living rather more messily than our moms would have. I admit to the last method of getting to the beach on our rare days off.

The Wichita House was made entirely of materials that are easy to clean. Like the 4D, it had downdraft ventilation — this time driven by the vacuum generated by a huge, rotating roof vent. The freely circulating air was kept clean by filters, greatly reducing the need to dust. What did accumulate was removed by a pneumatic vacuum system and sent outdoors. Sisyphean labours were further lessened by astute attention to details, such as draft-free control of air temperature and humidity that made bedclothes and even towels unnecessary. Ceiling-high shelves "ovolved" on an endless chain arrangement that brought the desired one within easy reach.

In addition, the Wichita House blessed its occupants by requiring virtually no maintenance or repair. There were no gutters to clean and no biodegradable roofing to replace or patch. (Biodegradability is not desirable in a house.) There was nothing that would need repainting and no drywall to crack. Termites, rodents, insects, rust and rot were permanently banished. Washing the windows and a bit of straightening up was about it. Then off to Lake Tehatchapoocoo.

There were some complaints that the Wichita House did not use natural materials, a comment that would be heard more loudly today. Fuller's answer was that aluminum, which he liked for its permanence, ability to be recycled and lack of need for upkeep, is a major part of the Earth's crust. Nothing unnatural about that. Plastics, when well used, are a much better application of petroleum than the wasteful burning of it. Moreover, his round structures, by laws of geometry, cover the most space with the least amount of any material.

Fuller also rightly claimed that little of today's conventional houses can be considered natural in the sense we usually mean. Examine the use of concrete and its necessary steel rebar, most roofing, tar paper, vapour barriers, insulation, paint, plywood and pressboard, glass, carpeting, countertopping, tile, brick, clock, pressure-treated wood, plumbing and electric fixtures, wire, pipe and the mechanical heating and cooling array. As for wood, while it is theoretically a renewable resource, in practice, most lumber companies do not plant and nurture nearly as much as they cut. And you have to remember the constant maintenance and replacement necessary to prevent the total failure of installed wood.

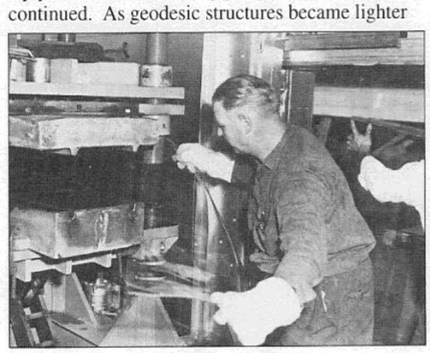
The only Wichita House built was used as a family dwelling, though not in the form intended by its designer. As a prototype, it proved Fuller's 1927 prediction: it weighed about 6,000 pounds, and Beech Aircraft offered a firm bid to produce it at a cost per pound almost exactly that of a 1946 automobile. That would be about $48,000 today. Alas, it never saw production. Beech and various bankers declined to put up the tooling costs, and Fuller had to return 3,700 unsolicited orders from folks who had thought enough of the idea to put their money on the line, sight unseen. It was the same old story.

The defeat annoyed Fuller, but it also spurred him to proceed with pure research instead of commercial ventures. He turned to cartography, discovering the most accurate representation of the Earth's landmasses on a flat surface, the Dymaxion Projection ["The Fuller Projection: Dymaxion Air-Ocean World"]. The spherical geometry necessary for developing the map led to what came to be called geodesic geometry. Modelling of the geometry led to the appreciation of the geodesic dome for which Fuller is famous.

Dome discoveries blossomed in the 1950s as Fuller inspired hundreds of students (me among them) to join the explorations. Many domes were built. As might be expected, some of the first were "stick-built" with the same materials and techniques as conventional houses. They are commonly available today, usually as kits that avoid the need to cut tricky angles. Advocates point to superior thermal performance, typically 30 percent better than that of familiar designs of the same size. Owners like the lack of faddish, arbitrary style exhibited by tract houses in the same category.

Detractors note that there is little price advantage to such geodesic houses and that they represent a worst-case example of peas-in-a-pod aesthetics. Moreover, if every stick-built single-family tract house in Los Angeles, California, were replaced with a stick-built dome, the major problems of Los Angeles would remain. In any case, such domes make little use of the economies of mass production, nor do they demonstrate many of Fuller's Dymaxion principles.

Nevertheless, Fuller and his wife Anne lived in a plywood dome for many years as his research continued. As geodesic structures became lighter



Production of plexi-glass and aluminum sheeting

Wichita House On the Move

by Jay Baldwin

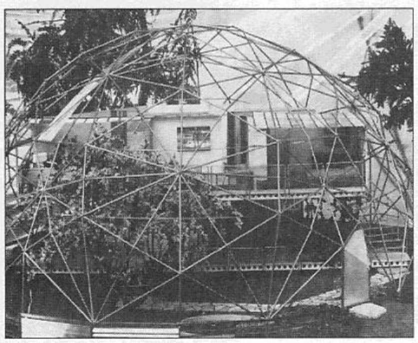
Bucky's famed "Wichita House" — the only Dymaxion House ever actually built and lived in — is now in the process of being dismantled and shipped to the Henry Ford Museum/ Greenfield Village in Dearborn Michigan [see *Trimtab* Vol 6 #4 for story]. There, it will be restored and put on permanent display as an example of Comprehensive Anticipatory Design. It is also a very pertinent example of "swords-into-plowshares" (Bucky would have said killingry into livingry); it was to have been produced on a military aircraft assembly line idled by peace in 1945. That would have meant thousands of jobs and many thousands of inexpensive, high-efficiency homes available to the house-hungry new families after the war.

After 46 years, the Wichita House stands dutifully beside its lake in the vast Kansas prairie. Vandalism and interior damage by aggressive (and filthy) raccoons have taken their toll since the Graham family grew up and moved out many years ago, yet the place is essentially whole and in good shape. Even with the tattered interior, the ambience is first-class, upper-deck 747 style elegance. There isn't a trace of mobile-home tacky.

But there *is* more than a trace of asbestos insulation on the Graham-added second deck. After that is removed by a licensed contractor sometime in May, a stalwart crew of six volunteers and myself will lovingly dismantle, record, mark and crate the Dymaxion's parts and send them to the museum.

and stronger, a new sort of Dymaxion House became possible. He called it the Garden of Eden, or Skybreak. The design called for a transparent geodesic shell, a "within-ness" under which the climate would be controlled. the central mast and complex network of tension cables found on the Wichita and 4D houses could be eliminated. More exciting, the house could be eliminated; with the geodesic shell as a weather shield, interiors could be anything the imagination might suggest. Fuller suggested living in an edible garden, with shade and privacy provided by trees, hedges, decks and storage walls. Local materials — adobe comes to mind — could be used to advantage and would not have to be weather-resistant. security could be handled in the usual way or with creatively placed blackberry thickets.

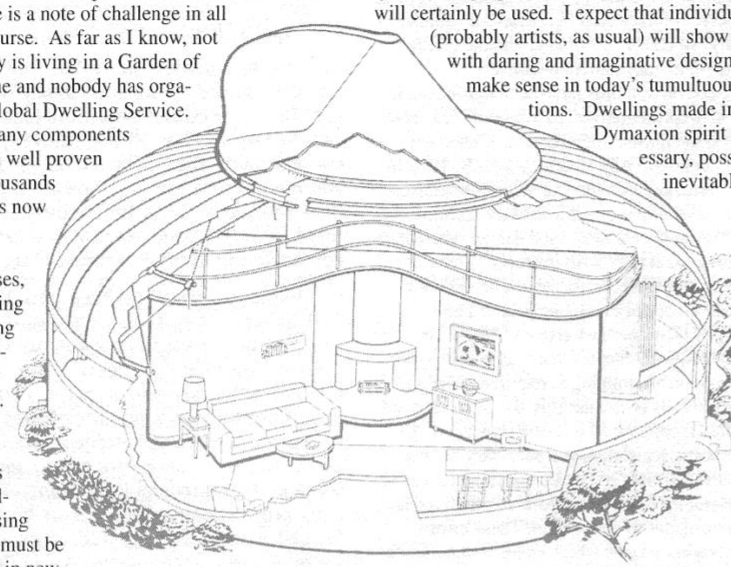
The Skybreak concept is a strong answer to critics who contend that manufactured housing must be dehumanizing, impersonal and peas-in-a-pod. The geodesic shells might appear similar, but at least they would be elegant models of mathematical principles. Beneath the shells could be interiors much more natural than any made of drywall and urethane-foam-stuffed furniture. Far from suppressing personal expression, the protective Skybreaks would invite and encourage a family to concentrate on creative action instead of on the enervating Cosmic Pile of Dirty Dishes and the upkeep of a static house-as-museum. It would be at once a nest, stage, studio and garden. It could be a net producer of energy and food.



Model of Skybreak Dwelling

Perhaps the most appropriate use of the Skybreak idea would be to shelter neighborhood community space of the sort proposed by Kathryn McCamant and Charles Durrett in their book Cohousing. Each family would have its own place, as well as a share in facilities, which might include gardens, play space, shops ad childcare. Another proposal is a senior citizen's enclave that is intended for use in a New England climate. Using technology developed at the New Alchemy Institute on Cape Cod and Windstar in Colorado, such a scheme is not practical to build and finance.

There is a note of challenge in all this, of course. As far as I know, not one family is living in a Garden of Eden dome and nobody has organized a Global Dwelling Service. Yet the many components have been well proven by the thousands of families now enjoying attached greenhouses, solar heating and cooling and photovoltaic electricity. There is a growing awareness that worldwide housing problems must be addressed in new ways.



Who will do the deed? One would hope that ingenuity and enterprise would rise to the occasion. There is some sign that this may be happening, particularly in the plastics industry. The Danish and Japanese have advanced the furthest with factory-produced housing. In Japan, there are housing showrooms where families can pick the designs and amenities from catalogues of components. A selection of full-size model houses demonstrates various arrangements. When the choices are made, computers order the automated factory to prepare the parts, finished right down to paint and carpets and ready to erect. Factory precision makes assembly rapid and free the defects common to craft building. There is little hint of peas-in-a-pod.

Although at this time no factory-built housing is nearly as efficient or complete as the Dymaxion designs, that day will come. As the need is becoming more insistent and the old ways are less able to cope and demand, a vital new industry is being born. It will probably not produce dwellings exactly as Fuller proposed, but many of his principles will certainly be used. I expect that individuals (probably artists, as usual) will show the way with daring and imaginative designs that make sense in today's tumultuous conditions. Dwellings made in the Dymaxion spirit are necessary, possible and inevitable. ▼

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Takedown will commence with the removal of the interior storage "pods" and the Dymaxion bathroom. This will protect the woodwork from weather and accidental damage. Then, working backwards from (incomplete) assembly instructions furnished by Scott Hudson, and blueprints and photos extracted from the Fuller Archives by Bonnie Goldstein et.al. "thinking Bucky backwards," we'll slowly take the main structure apart.

It'll be tricky business: not only is the whole thing under tension, there are hundreds of rivets to drill out, and about 600 feet of recalcitrant fiberglass/rubber waterproofing compound to be split and removed. The final phase of the takedown must be done in one continuous burst of energy because the house loses its structural integrity when we finally release the tension that makes it strong. A strong wind could ruin it then. We'll have to work fast.

Preparing for this project has been enlightening. For instance, it is obvious the the Wichita House is not yet ready for production, just as Bucky insisted to the dismay of his stockholders. It's conceptually complete, but needs more work on many critical details, especially in the climate control systems. Also, certain structural details need to be modified for added stiffness and resistance to galvanic corrosion. But the basic idea is fine; it's a glittery-clear example of Bucky's thought. It's an idea that should be pursued further. ▼

As we go to press, the month-long disassembly of the Wichita House has been successfully completed by the Henry Ford Museum & Greenfield Village. Jay Baldwin and his volunteer crew of BFI members will tell their tales in the next issue of Trimtab.