The Pillow Dome

by Jay Baldwin 1985
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Ever since Bucky first demonstrated the promise of geodesic structure, designers have been attracted by the idea of transparent domes. Making practical ones, however, has proved to be a challenge; high construction costs, water leaks, and poorly controlled heat flow (unseemly these days) have been among the problems even in otherwise magnificent domes.

In 1969, while working as resident faculty at the counter-culture Pacific High School in Northern California, I hit upon the idea of skinning a tube-framed dome with individual, inflated transparent vinyl triangles. A 24 ft prototype was built and lived in successfully, and Bucky ordered one for use on his Bear Island off the Maine coast. In all, six pillow domes were made before it was discovered that vinyl exudes carcinogenic gases. It also lasts only about six years before sunlight degradation takes its toll. At the time, no other suitable skinning material was available, so we curtailed further development.

Ten years later, while working at The New Alchemy Institute on Cape Cod, a serious problem arose in the Institute's famous solar greenhouse, the "Ark," one of the very first low-energy greenhouses. The Ark houses a growing environment consisting of intensive organic gardens, irrigated by the "exhaust" from large, transparent tanks containing fish. The-tanks also serve as an effective heat sink, allowing an indoor climate warm enough to grow bananas in February, in New England, with no fossil fuel heat source.

The problem was that the hot, humid atmosphere was rotting the building's structure. Because of the sensitivity of the fish to fungicides, the wood could not be protected effectively. Moreover, the air circulating fans used electricity from a nearby nuclear facility, a matter highly antithetical to the philosophy of the New Alchemy Institute.

New Alchemy already had a dome, a severely deteriorated 2x4 and fiberglass 31 footer. I proposed to replace that with a. modem version of the pillow dome done in aluminum and Tefzel, a DuPont material related to Teflon. Tefzel is inert, it does not exude anything nasty, does not smell, and is resistant to most chemicals. As far as is known it does not degrade in sunlight at all. It is more transparent than glass, and, unlike nearly all other glazing materials, it admits ultraviolet light which seems to deter

plant molds. Other attributes include a resistance to the passage of long-wave infra-red light, giving a useful "greenhouse effect", strong resistance to puncture and potato chip bag type "zipping" of ruptures; toughness (the first test pillow was used as a trampoline); and automatically sheds dirt which will not adhere to the ultraslick surface.

DuPont generously agreed to donate the material. and their local distributor, American Durafilm of Natick, Massachusetts, donated the fabrication of the pillows. Other funds were furnished by a grant from the National Endowment for the Arts. The New Alchemy team was advised by John Todd (one of the Institute's founders), captained by John Wolfe, who also did solar calculations, with horticulture by Liz Fial. Daryl Bergquist developed the instrumentation and aided construction.

The pillows were made up in three layers, heat-scaled together with a seam 3 inches inboard from the edge of the material. A gas-loading valve was installed near one corner. Pillows are installed on the tubular frame by means of long, semi-cylindrical clamping strips fashioned from slit PVC water pipe. The 3 inch flaps on each pillow are overlapped "downhill" under the clamping strips before being secured to the frame with 3/16 inch poprivets spaced every 6 inches. This produces a reliable, mechanical, waterproof seal well able to withstand heavy weather conditions and expansion contraction that has engendered so many leaks in other domes. The pillows are cut from roll stock with no waste.

Inflation is with Argon gas at a pressure of 1/2 lb/ft2. Argon is inert, nontoxic, and about a 30 percent better insulator than air. The pillows end up about 4 inches thick at the center, giving an effective, triple-glazed, transparent, insulated panel of about the same transmissivity as one layer of low-iron solar glass. The pillows also offer a certain amount of fire protection – if one should be punctured by a flame, the inert gas would quickly snuff it out. Another attribute is the very good acoustics. The bulged pillows completely kill the obnoxious echo usually found in domes.

The 31 ft diameter, 3 frequency, 3/8ths spherical frame was made from I inch 6061 T6 aluminum schedule 40 water pipe -a commendable material. Rather crude hubs of stamped aluminum sheet were covered with shells adapted from camping pot lids. Inside the dome, the frame is insulated with I inch closed-cell pipe insulation slit in half lengthwise and protected with a thin sheet metal valance. Five upper and five lower triangles, opened by spring struts, provide ventilation. They are gasketed well enough to permit only 1/10th of an air change per hour when closed.

When the I pillows are inflated, the entire dome is put under compressive load that tends to oppose the considerable wind lift, This preloading, together with the anchoring provided by buried concrete blocks tied to the lowest hubs, has withstood 30 inches of snow load and winds well above 100 mph. This may be considered good performance from a structure that weighs but 1/2 lb/ft2 of floorspace (less than 500 lbs total). The light weight not only results in low shipping costs – the whole thing will easily fit into a small station wagon – it requires no foundation. The only base under this dome is a perimeter insulation ring of 2 inches styrofoam board stock buried 2 feet deep.

The physical performance has been good. The biological performance has equaled the original New Alchemy Ark in output per square foot, that is, commercial production quantities. Moreover, the pillow dome's natural air circulation patterns have eliminated the need for that nuclear fan. The dome also casts but 1/5th the shadow of a more conventional greenhouse, important for winter growing.

As with any prototype, there have been problems, but nothing that cannot be easily solved by a tooled-up production version. Conservative cost estimates for a mass produced pillow dome in the 1,000 ft2 size range is about $12/ft2 including labor, installed. To say the least, competitive. Wide use could greatly reduce the money flowing out of northern states to states with better farming weather, making it possible to raise food locally, all year

What of the future? We can now make strong, reliable, ultralight, insulated transparent domes. If the central pillow membrane was to be of Southwall Corporation's Heat Mirror", thermal performance would be even better. Day Chahroudi's Cloud-Gel automatic shading material (now nearing production) could also be used, giving complete solar control and making a true "organic" building system. This combination at last makes possible the fabled and highly desirable "Garden-of-Eden" dome - Bucky's " membrane under which we control the weather."

Finally. it becomes reasonable structurally and energetically to live in the garden and have buildings that *make* more than they *take* from nature. There are other ways to accomplish that, of course, but the time seems right for further development of the possibilities offered by the combination of pillow dome, New Alchemy indoor agriculture, and promising new materials. Have at it! There's no patent on the idea, nor can there be. I'm gonna have my bed over there. under the cherry tree. .