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Ephemeralization

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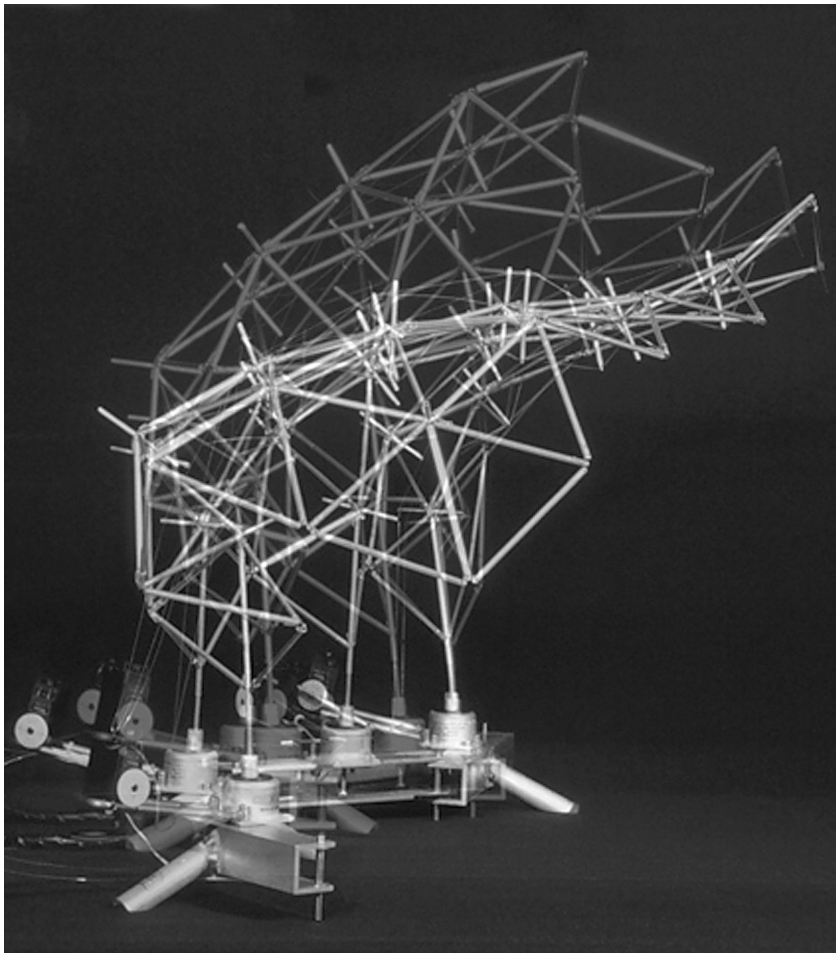
"We may say that thinking about the truth alters truth, but only to the extent of defining it. We may always clarify and redefine the truth by making it more comprehensively considerate and more incisively exquisite. Truth alters truth only by refining the definition. The substance of the sensing and instrumental control of the physical means of communication is always refinable and tends toward the ephemeralization of doing ever more with ever less, but you can never get to the exact, most economical statement of the truth, for the very communication will have ephemeralized to pure metaphysics. Truths are like generalized principles: interaccommodative and nonintercontradictory. Truths are special case realizations of the generalized principles; by these very aspects are they discovered to be truths."

—R. Buckminster Fuller
Synergetics, 504.11

Introduction

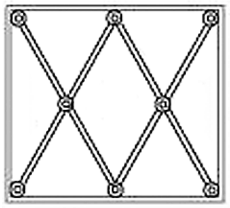
Our capabilities of utilizing kinetics in architecture today can be extended far beyond what has previously been possible. This article looks at the potential of advanced kinetic architectural systems; what they are, what they can do for us, and how we can go about designing them. Advancement will only be accomplished when kinetic structures are addressed not primarily or singularly, but as an integral component of a larger system that takes advantage of today's constantly unfolding and far-reaching technology. Necessary are the use of advanced computational design tools, material development, and embedded computation. It is important to point out that this article shall remain safely grounded in science-fact and not science fiction. In other words, to make convincing extrapolations based on where we stand today through inclusively appreciating and marshalling correctly the existing facts with respect to technological development. The irony is that from an architectural standpoint we are in a relative infancy even with respect to our extrapolations, further exacerbating the matter is the foolishness to name what we are experiencing in terms of general technological advance as a revolution; it is an evolution, to which an end cannot be predicted outside the parameters of political and economical entanglement.

Prior to explicitly defining why advanced kinetic architectural systems will be useful or even necessary, we will state simply that the motivation lies in creating spaces and objects that can physically re-configure themselves to meet changing needs. Such systems arise from the isomorphic convergence of three key elements: structural engineering, embedded computation and adaptable architecture as situated within the contextual framework of architecture.



Kinetic Architecture: A Definition

Concerns in structural engineering will focus explicitly upon kinetic design. Kinetic architecture is defined generally as buildings and/or building components with variable mobility, location, and/or geometry. Structural solutions must consider in parallel both the ways and means for kinetic operability. The ways in which a kinetic structural solution performs may include among others, folding, sliding, expanding, and transforming in both size and shape. The means by which a kinetic structural solution performs may be, among others, pneumatic, chemical, magnetic, natural, or mechanical.



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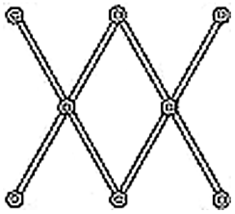
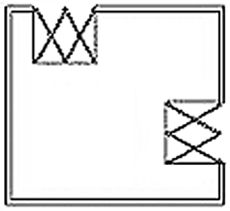
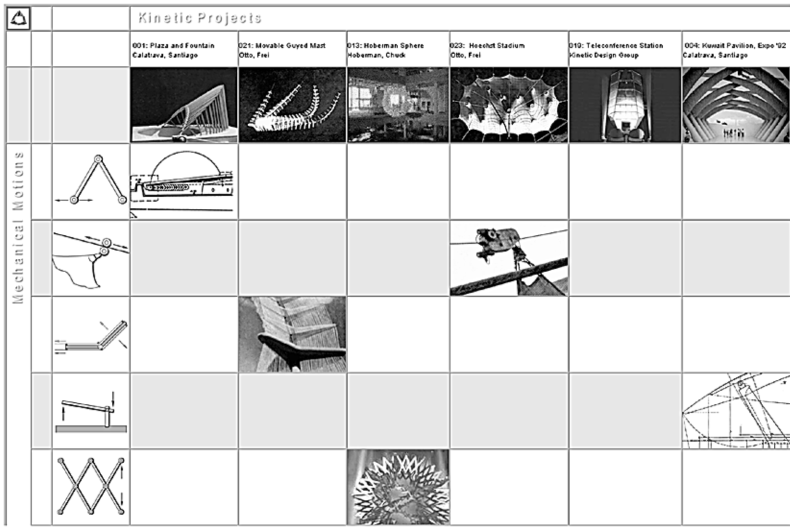


Deployable



Dynamic



Mechanical Motions

Kinetic Typologies

Kinetic structures in architecture are classified here into three general categorical areas:

Embedded Kinetic Structures

Embedded Kinetic structures are systems that exist within a larger architectural whole in a fixed location. The primary function is to control the larger architectural system or building, in response to changing factors.

Deployable Kinetic Structures

Deployable Kinetic structures typically exist in a temporary location and are easily transportable. Such systems possess the inherent capability to be constructed and deconstructed in reverse.

Dynamic Kinetic Structures

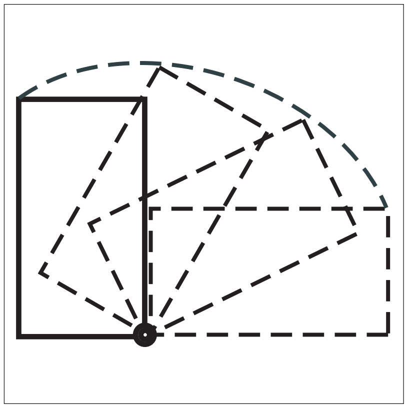
Dynamic kinetic structures also exist within a larger architectural whole but act independently with respect to control of the larger context. Such can be subcategorized as Mobile, Transformable and Incremental kinetic systems.

Controlling the Ways: Kinetic Function

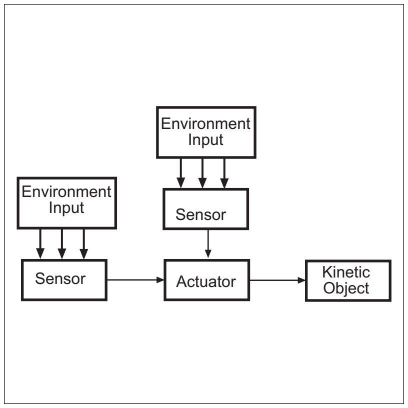
The ways can be described diagrammatically as mechanical motions. Contemporary innovators such as Chuck Hoberman and Santiago Calatrava continue to demonstrate that the last word has not been spoken in novel kinetic implementation at an architectural scale. Yet, we as designers ought to focus our attention in this area upon the vast wealth of resources that have been accumulated over numerous centuries of engineering. There are many great scientists of a thousand years ago who would have had no difficulty understanding an automobile or an engine or a helicopter and certainly not the most advanced architectural system. The craftsmanship would have been astonishing but the principles straightforward with respect to an understanding of the novel material properties. Materiality will prove to be the one great promise for advancement in this area primarily as a result of technology providing both an unprecedented vision into microscopic natural mechanisms and advanced manufacturing of high quality kinetic parts with new materials such as ceramics, polymers and gels, fabrics, metal compounds, and composites with unprecedented structural properties. The integrative use of such materials in kinetic structures facilitates creative solutions in membrane, tensegrity, thermal, and acoustic systems.

Controlling the Means: Embedded Computation

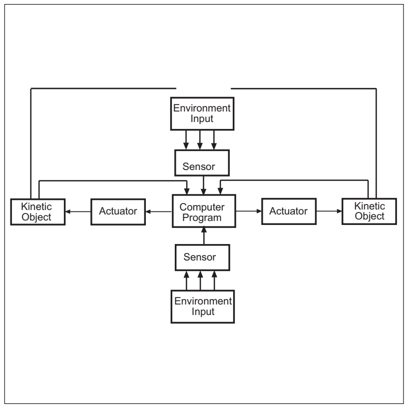
The means can be described diagrammatically as the controlled source of actuation. If we were to show the same great scientist of the past a television or a computer or a radar, it would have appeared magical to them. The difficulty for them would not have been one of complexity; but rather they would have been lacking in the mental framework required to conceptualize such non-mechanistic devices. Today it does not take much effort to extrapolate existing computation as a means for kinetic actuation. From an architectural standpoint the implementation of embedded computation has taken an interesting foothold. Currently there is an explosion of research and development into embedded, networked computing. Numerous projects have demonstrated great success in home automation and will serve as the foundation for the integration of actuators for the explicit means of controlling kinetic motion. Specifically we are interested in addressing embedded computation as a control mechanism for kinetic function to accommodate and respond to changing needs. Such systems will be utilized to interpret functional circumstances and direct physical movements to adaptively better suit changing human needs. The issue of controlling kinetic motion is central to issues of design and construction techniques, kinetic operability and maintenance, as well as issues of human and environmental interaction. Outlined below are the six general types of control, which can possess both centralized and decentralized case-specific advantages:



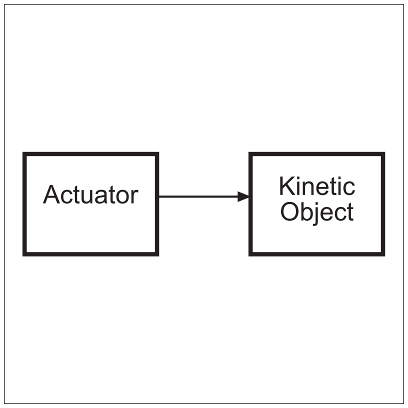
Internal Control
Systems in this category contain an internal control with respect to inherent constructional, rotational, and sliding constraints. In this category falls architecture that is deployable and transportable. Such systems posses the potential for mechanical movement in a construction sense, yet they do not have any direct control device or mechanism.



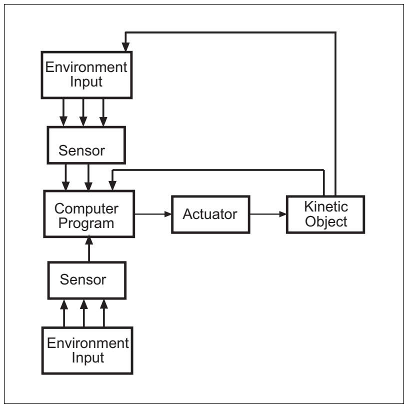
In-Direct Control
In such systems, movement is actuated indirectly via a sensor feedback system. The basic system for control begins with an outside input to a sensor. The sensor must then relay a message to a control device. The control device relays an on/off operating instruction to an energy source for the actuation of movement. We define In-direct control here as a singular self-controlled response to a singular stimulus.



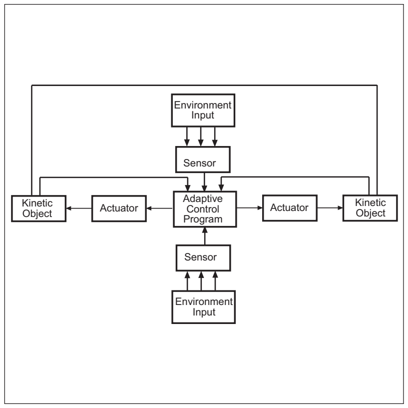
Ubiquitous Responsive In-Direct Control
Movement in this level is the result of many autonomous sensor/motor (actuator) pairs acting together as a networked whole. The control system necessitates a “feedback” control algorithm that is predictive and auto-adaptive.



Direct Control
In this category, movement is actuated directly by any one of numerous energy sources including electrical motors, human energy or bio-mechanical change in response to environmental conditions.



Responsive In-Direct Control
The basic system of operation is the same as in In-Direct Control systems, however the control device may make decisions based on input form numerous sensors and make an optimized decision to send to the energy source for the actuation of movement for a singular object.



Heuristic Responsive In-Direct Control
Movement in this level builds upon either singularly responsive or ubiquitously responsive self-adjusting movement. Such systems integrate a heuristic or learning capacity into the control mechanism. The systems learn through successful experiential adaptation to optimize a system in an environment in response to change.

Novel Applications for Kinetic Adaptability

While there may be many reasons for employing kinetic solutions in architecture we can always rest assured that they are a means to facilitate adaptability. Adaptability is taken in the broadest sense to include issues such as spatial efficiency, shelter, security, and transportability. Such systems that are inherently deployable, connectable, and producible are ideally suited to accommodate and respond to changing needs. An adaptable space flexibly responds to the requirements of any human activity from habitation, leisure, education, medicine, commerce, and industry. Novel applications arise through addressing how transformable objects can dynamically occupy predefined physical space as well as how moving physical objects can share a common physical space to create adaptable spatial configurations. Applications may range from multi-use interior re-organization to complete structure transformability to response to unexpected site and program issues. Specific applications may include intelligent shading and acoustical devices, automobile-parking solutions, auditoriums, police box stations, teleconference stations, devices for ticketing and advertising, schools and pavilions, as well as flexible spaces such as sporting, convention and banquet facilities. Other spaces of consideration are those with necessary fixed exterior configurations such as airplanes, boats, transport vehicles, and automobiles. Through the application of intelligent kinetic systems, we can also explore how objects in the built environment might physically exist only when necessary and disappear or transform when they are not functionally necessary. Kinetic adaptability further considers the rapidly changing patterns of human interaction with the built environment. New architectural types are emerging and evolving within today's technologically developing society. These new programs present practical architectural situations for unique and wholly unexplored applications that address today's dynamic, flexible, and constantly changing activities.

Future human interaction with the built environment is extremely difficult to predict even as science-fact extrapolations because it is ensnared with contradictions. In the example set forth by Arthur Clarke a really perfect system of communication would have an extremely inhibiting effect on transportation. Less obvious is the fact that if travel became nearly instantaneous, would anyone bother to communicate? Our cities are the result of our mastery over neither. A topic of great interest today is the effect of our current mastery of communication on urban built form. What would be the effect if our mastery over travel had preceded that of communications? More relevant to applications of intelligent kinetic systems is the still science fiction issue of planetary engineering or climate control. If climate control were localized by architectural means at an urban scale would there be any desire to investigate planetary engineering given the potentially adverse effects on terrestrial equilibrium?

Intelligent Kinetic Systems and Material Reduction

What we are describing then with advanced kinetic systems in architecture is a structure as a mechanistic machine that is controlled by a separate non-mechanistic machine: the computer. An interesting phenomenon can be observed when we look at the higher levels of control. The engineer Guy Nordenson describes the phenomenon in embedded kinetic systems as creating a building like a body: a system of bones and muscles and tendons and a brain that knows how to respond. In a building such as a skyscraper, where the majority of the structural material is there to control the building during windstorms, a great deal of the structure would be rendered unnecessary under an intelligent static kinetic system. If the building could change its posture, tighten its muscles, and brace itself against the wind, its structural mass could literally be cut in half. In deployable and dynamic kinetic systems as well, much of the structure will be reduced through the ability of a singular system to facilitate multi-uses via transformative adaptability. Buckminster Fuller who coined it "Ephemeralization" first illustrated this concept of material reduction. Robert Kronenburg aptly illustrates the advantage of such systems in that buildings that use fewer resources and that adapt efficiently to complex site and programmatic requirements are particularly relevant to an industry increasingly aware of its environmental responsibilities.

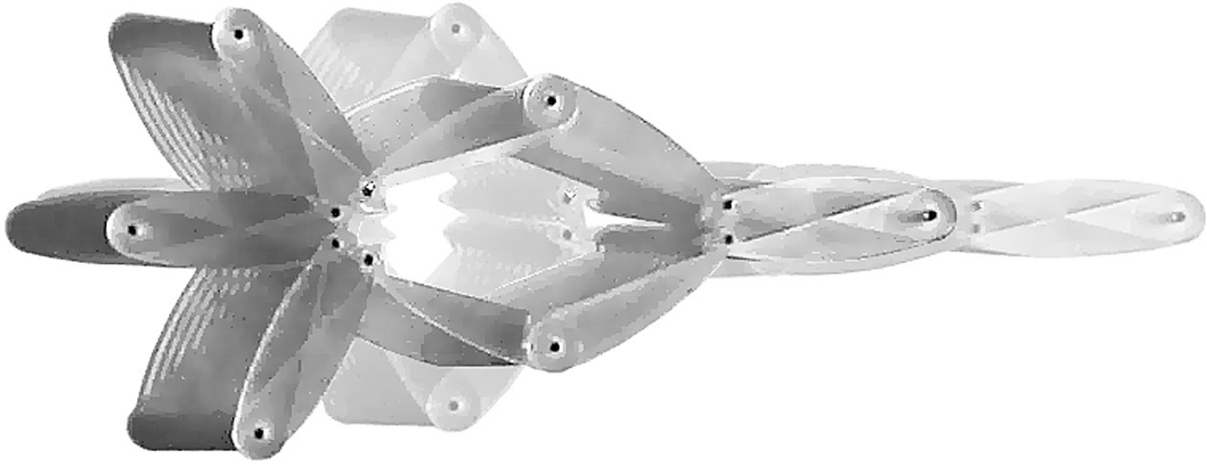
Extrapolating Precedent

Numerous full-scale "Intelligent Environments" have already been successfully developed with seamlessly embedded computation into built form. The primary target clientele are the military, the elderly, and the handicapped, typically in that order. Not surprisingly, the vast majority of the work has been highly tectonic and focused on managing human interactions and novel applications of Internet Technology. The subject matter has been generally been limited to that of the intelligent office and the intelligent house with a few exceptions with the primary goal aimed at enhancing everyday activities.

The major problematic of what has been accomplished outside the field of architecture is the myopic nature of enhancing everyday activities. When embedded computation is employed to control physical built form the most obvious application should be to foster an extension of manual capabilities. With due respect to the advantages such systems can provide to the elderly and handicapped they are at best equalizing the current advantages of built form, and not extending them. Architects need to design with an understanding of the current capabilities of embedded computation that have attained sufficient maturity to act as independent subsystems that can be beneficially incorporated into kinetic design. Ironically the most intelligent environments built to date have been constructed for space travel where the environmental conditions are extreme yet relatively constant and yet a residential house in Phoenix, Arizona typically could not be identified as different from one in Anchorage, Alaska. The primary goal of intelligent kinetic systems should be to act as a moderator responding to change between human needs and environmental conditions.

Another relevant area coming out of A.I. (where first?) is research into the development of robots. Unfortunately, while highly sophisticated, robots are typically autonomous with respect to the built form they inhabit and tend to be fixed function devices. Not only should robots become mutating, multi-function machines but also they need to be developed with respect to the architectural built form they inhabit. If the architecture itself were embedded with the intelligence of a robot with the capability of completely controlling the built form, then the development of single-task autonomous robots would by all practical means be rendered negligible.

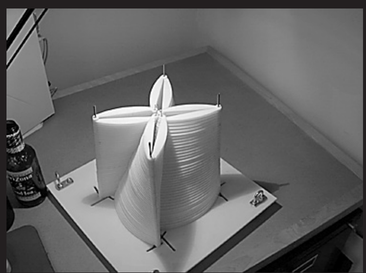
Perhaps the most applicable research to draw upon in designing intelligent kinetic systems lies in an area of study within Active Control Research that focuses upon the design of structures to control the movements of a building through a system of tendons or moving masses tied to a feedback loop to sensors in the building. Changes are brought about by both environmental and human factors and may include axial torsion, flexural instability, and vibration and sound. Such systems have been successfully employed in numerous large buildings situated in high-wind or earthquake-prone locations.



Conclusion

It is difficult to see if advanced kinetic architectural systems are far on the horizon or inevitably in the very near future. To extrapolate the existing into a future vision for architecture is a conundrum residing in the hands of architects directing the future of their profession. Adaptive response to change must intelligently moderate human activity and the environment and build upon the task of enhancing everyday activities by creating architecture that extends our capabilities. Such systems introduce a new approach to architectural design where objects are conventionally static, use is often singular, and responsive adaptability is typically unexplored. Designing such systems is not inventing, but appreciating and marshalling the technology that exists and extrapolating it to suit an architectural vision. Architects will inevitably hear that "it cannot be done," and to this should recall that commercialized electric light was not long ago thought impossible, that it was thought a man would suffocate on a locomotive if he were to travel at a speed exceeding 30 miles an hour and of course the impossibility of heavier-than-air flight. Architects need to grasp a vision that will harness technology transfer from "outside" fields and prevent contradictions in human interaction with the built environ-

Kinetic motion



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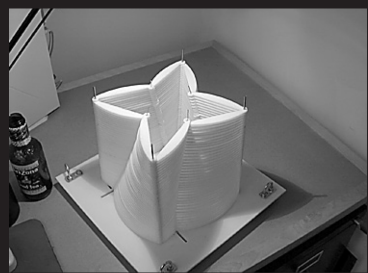

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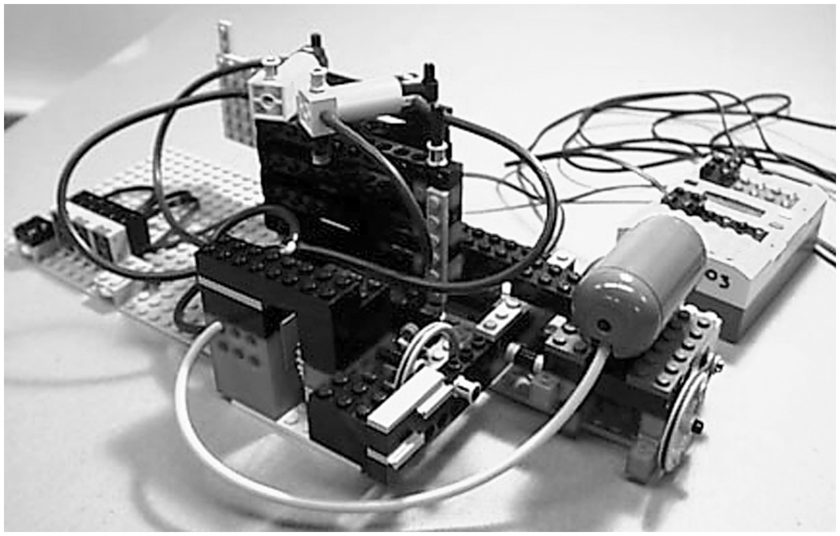

ment. To a great extent the success of creating intelligent kinetic systems in architecture will be predicated upon the real-world test-bed. Applications must consider the capability for such systems to yield real-world benefits. Actual construction and operation will allow architects to develop realistic consideration of human and environmental conditions, and to overcome simplified assumptions about the costs of manufacture and operations. The result will be architecture of unique and wholly unexplored applications that address the dynamic, flexible and constantly changing activities of today and tomorrow.

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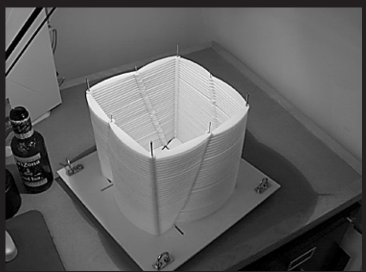

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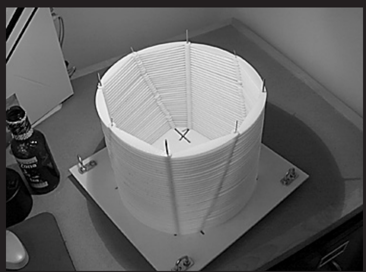

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