Eureka and Serendipity: The Rudolf von Laban Icosahedron and Buckminster Fuller's Jitterbug

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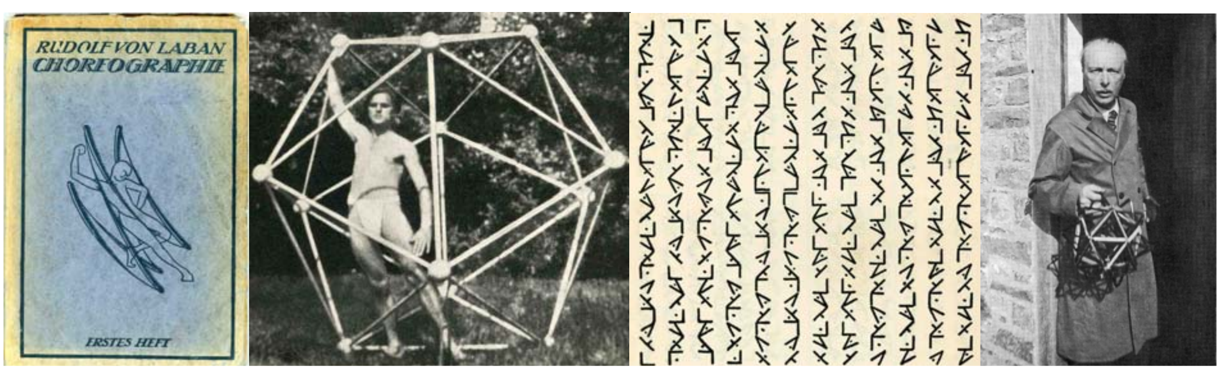
Abstract

Rudolf von Laban's (1879-1958) famous dance notation (1926) is based on the icosahedron. Laban strongly believed that our anatomy is built according to the laws of what he called a "dynamic crystallization". The rational six-sided cube could not describe the movement of the human body sufficiently. The idea of using the twenty-sided icosahedron as a matrix was a serendipitious discovery of Laban and it took place long before the scientific boom started around the icosahedron with the finding of the icosahedral viruses in 1959 and quasicrystals in 1984, which all are based on a "dynamic" or icosahedral symmetry. Laban's idea of the reunification of mind and body through a "hands-on" icosahedron model is a good example of the avant-garde movement just about 100 years ago.

Buckminster Fuller's (1895-1983) discovery of the "jitterbug" transformation (1948) was his "eureka" experience, and "Eureka" was the title of an emotional paper he wrote in the same year. It is the favorite "hands-on" model to demonstrate the "synergetics" concept. It states that regular geometric bodies do not stand statically next to one another but they are subjected to various phases - the tetrahedron, octahedron, icosahedron, cuboctahedron – of a process of mutual transformation. The epoch-making confirmation of the "jitterbug" came only after Fuller's death. It will be shown that this kinematic novelty led to more exciting inventions and "hands-on" for performances.

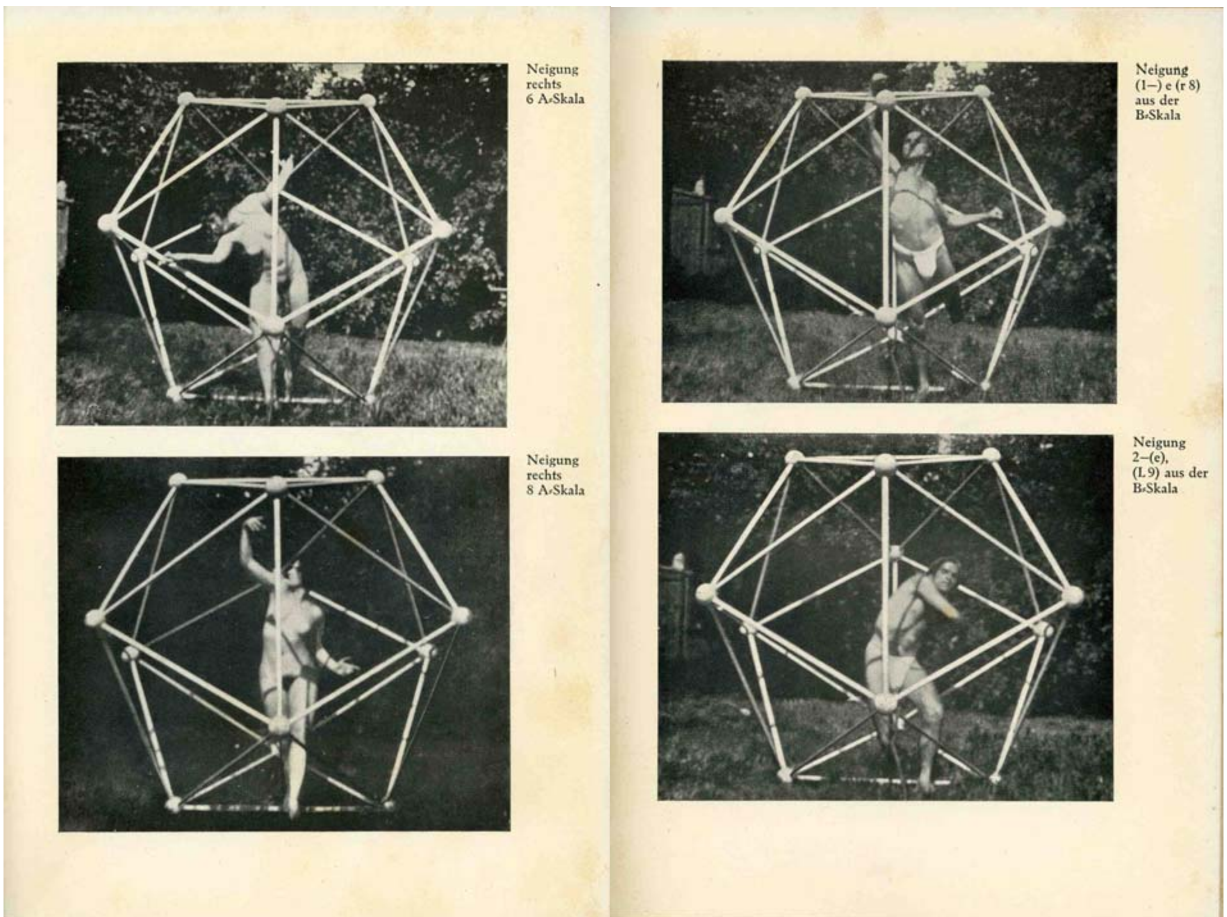
The epilogue "Eureka, Serendipity and Hands-on" is a reminiscence on the "hands-on" movement in the sixties.

The Laban Icosahedron

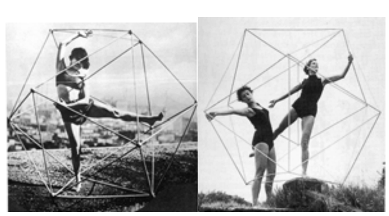


Frontispiece of "Choreographie". Laban and his dance notation, published 1926 [1] Laban with icosahedron 1938

Rudolf Laban studied architecture at the ecole des beaux arts in Paris. At age of 30 he moved to Munich and began his research on "Bewegungskunst", or the movement arts. In 1915 Laban established the Choreographic Institute in Zürich and later founded branches in Italy, France, and Europe. Laban was a serendipitious discoverer who produced many ideas and then let his students develop them. His greatest contribution to dance was his 1926 publication of "Choreographie" [1], a dance notation system that came to be called Laban notation. It is still used as one of the primary notation systems for movement in dance. In 1930 Laban became the director of the Allied state theatres in Berlin but had to leave Germany 1938 for Great Britain. We have this affectionate photo of Laban holding his favorite icosahedral model in his hand, that was one of the important thing he took with him when he went to in England. [2] The idea of using the icosahedron as the scaffolding of the kinesphere in practicing movement arose spontaneously from the study of movement and dance and is based on the inherent laws of natural movement, which serendipitously came to light in Laban's professional activity as an architect, as a dancer and dance-teacher. The icosahedron illustrates Laban's theory of space harmony in which clusters of atoms are bound together by simple forces that create an unusual stability when the cluster has the exact number of atoms needed to form a regular icosahedron. Part of Laban's system of choreutics, the theory of the icosahedron supported his view of human movement as a continuous creation of fragments of crystalline forms. This led him to classify movements as Plato had classified the regular solids. He continued to teach and do research in Britain until his death in 1958. [3]



Pages from Choreographie, 1926 [1]. Rudolf von Laban's "dance farm" 1913-1917 at the foot of Monte Verita (mountain of truth) near the lake Maggiore in Ascona (Switzerland). The local community was very tolerable towards the different utopian communities, who gathered there, coming from all over Europe. [4]



The Buckminster Fuller Jitterbug

The "heureka" polyhedron. Symbol of the Swiss national science expo 1991. It was a giant "Jitterbug" with a side length of 8 meter (26 feet). Transformed hydraulically from an octahedron to an icosahedron into a cuboctahedron [5]

Beneath the date 25 April 1948 in Buckminster Fuller's research papers on geometry one finds the entry "Eureka, eureka- this is what Archimedes sought and Pythagoras and Kepler and Newton - and eureka again!" Fuller had found his philosophers stone. Characteristically, it was the complete opposite of a "stone": not a solid body at all, but a fluid motion in which one body dissolves into another, one spatial figure develops from the other, just like in a dance. Hence the name "jitterbug", a ballroom dance, (popular in the 1940's) that Fuller was reminded of when, he discovered the transformation. It cast new light on the basic geometric configurations and their relationship. In Fuller's jitterbug, the elementary geometric forms that have stood together since Plato's time as a set of regular solids are shown now to be a phase transition in a single process of metamorphosis. [6]

Buckminster Fuller was successful in modeling quantum effects that brought out Platonic solids in a new light. Fuller interpreted them as phases of a dynamic transformation process that manifests itself in a spiral-shaped contraction. The system oscillates, expands and contracts over the octahedron, icosahedron, cuboctahedron and vise versa. The jitterbug as sort of a "quantum machine" is Fuller's most central discovery.

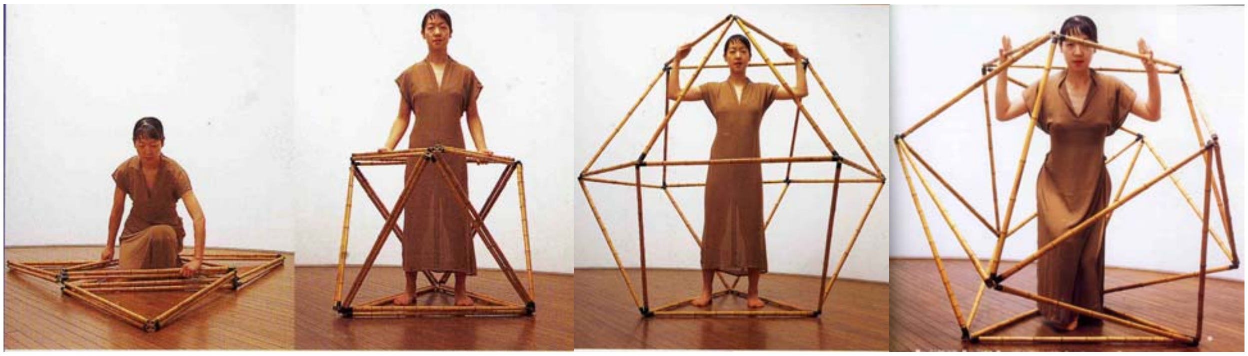
Fuller demonstrated the jitterbug transformation with a simple "hands-on" model made of bamboo rods of equal length with flexible nodal connectors made of rubber hose. This allows the jitterbug to be folded in any direction. It is this “twinkling of angles” that is the essence of the transformation. The octahedron can be twisted further, and the entire system collapses into a “super triangle” consisting of four pairs of triangles, which then can be folded into a tetrahedron. Finally, it is possible to fold it into one single triangle, congruent with the basic surface of the cuboctahedron, but now with eightfold edges. This is the zero phase of the jitterbug and Fuller’s theory was (similar to the Greek’s stoicheia) that everything started with a triangle. When we view the jitterbug as an unfolding of a triangle, the surprise is that it suddenly forms configurations that consist not only of triangles but also of squares. Fuller spoke and wrote extensively on the geometric principles demonstrated by the jitterbug and how it could help understand the abstracted sciences of chemistry and physics by allowing us to see and feel movements that are normally occurring invisibly all around us. [7]

The early models of the jitterbug were mechanically very unstable structures, requiring a supporting armature to keep them from collapsing, until 1974 when a very special hinge joint was discovered by Dennis Dreher [8], who was working with Fuller at the time. This joint is called a constant dihedral hinge in the shape of a Maraldi angle (109.5 degrees) and it is what at last makes the smooth motion of the jitterbug possible. This hinge was adapted for the giant “Heureka” polyhedron in 1991.

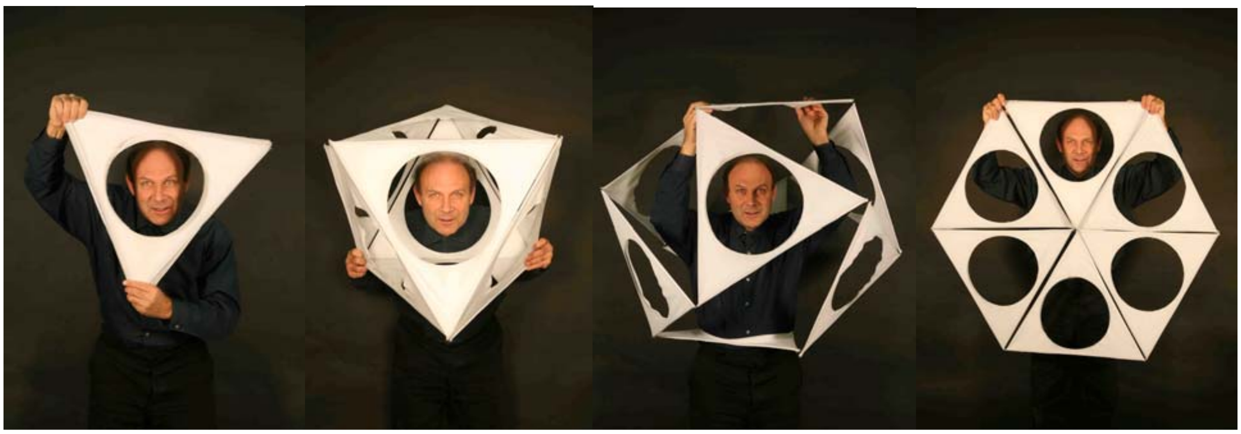
The principles of the jitterbug were generalized by Buckminster Fuller’s student Joe Clinton in 1972. It is remarkable that when Joe Clinton showed his discovery of the double tetrahedron-octahedron jitterbug to Buckminster Fuller, Bucky was at first irritated because he realized that the jitterbug was not the only transformation and the principle could be even expanded to other Platonic and Archimedean solids. The Jitterbug inspired many others to establish similar transformation and there have been wonderful toys and publications on these. (Hiroshi Tomura’s Tom cube, 1974, Xavier de Clippeleir’s Rhombic 1990). Hugo F. Verheyen (1981) gave us the complete set of jitterbug transformations [9]. His article ends with an array of applications in architecture, engineering, art and mathematics, such as Fuller would have wanted it. Hugo F. Verheyen gave the jitterbugs also a new name and called them dipolygonid, which means the faces of the polygons (like was also the case of Joe Clinton’s jitterbug) were in double layers, one rotating left and the other one to the right. With a set of only seven different types of jitterbugs or dipolygonids (the five platonics and the cubocta- and icosidodecahedron) one can form all the 5 platonic and 13 archimedian solids, that means more than 18 different polyhedra!

The Jitterbug can also be demonstrated as a compound of connected cells as a space filling structure. An ensemble of two types of cells of alternating octahedra and cuboctahedra. Fuller named the cuboctahedon vector equilibrium because it is the equilibrium position between a right and a left handed jitterbug. If we collapse the cuboctahedra in accordance with the motion pattern of the jitterbug, in order to pass through the icosahedral phase to the octahedral, the same number of octahedra that takes to fill the gaps can expand to pass though the reverse process to become cuboctahedra. The whole process turns to be a complete exchange between two configurations. [see pictures next page]

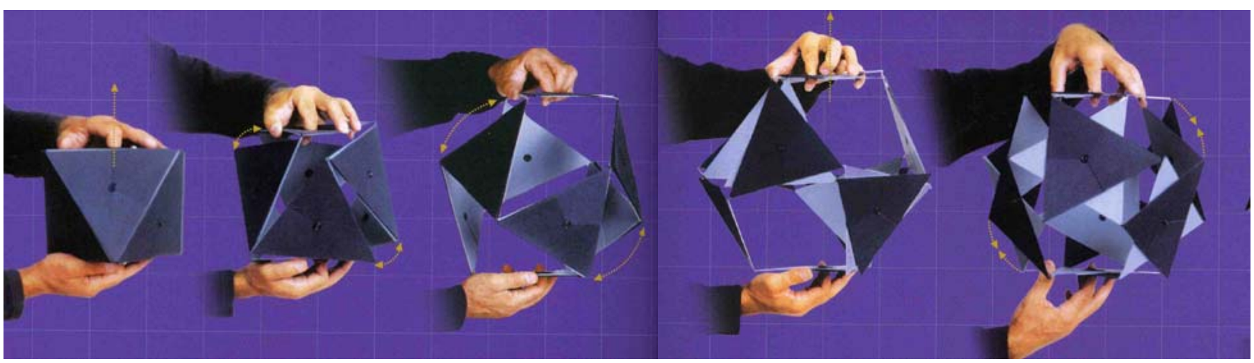
There were also many attempts to make the Jitterbug as a large outdoor monumental sculpture. The architect Thomas Zung, a partner of Buckminster Fuller has a project ready in his desk to set up three big mechanized jitterbugs for a public place, each one moving in a different rhythm from the others. Carl Solway of Cincinatti, who was the curator of Buckminster Fuller’s art work wanted to set up a huge jitterbug suspended from a building, but the project was never realized and instead a large tensegrity sculpture was set up when Bucky (nickname for Buckminster Fuller) was still alive in 1981. The biggest jitterbug ever realized was through my initial effort and became the landmark of the Swiss science expo 1991 in Zurich. The sides had a length of 8 meter and it was moved hydraulically from three “Maraldi” hinges at the bottom. When it opened, its height doubled and the volume five-folded. After three months in operation it collapsed into the tetrahedral position, because the steel hinges and the connections to the triangles made of composite polyester were not well enough engineered.



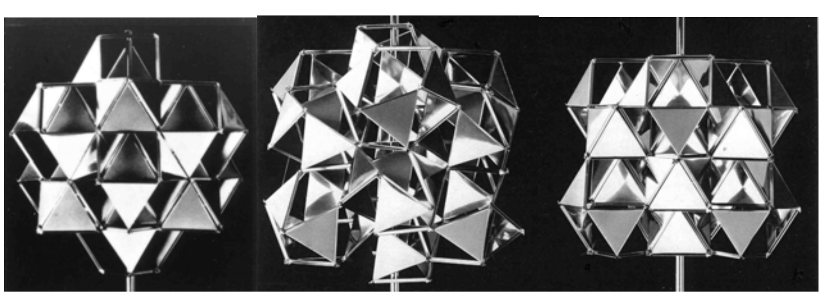
Tomoko Sato performs a "synergetics" dance. Bamboo rods "hands-on" jitterbug with rubber connectors [10]



Single cell "hands-on" jitterbug model in a "kinematic serendipity" performance, made from cloth and carbon rods



"Hands-on" Joe Clinton jitterbug, 1972. The outer triangles rotate to the right, the inner triangles rotate to the left [10]

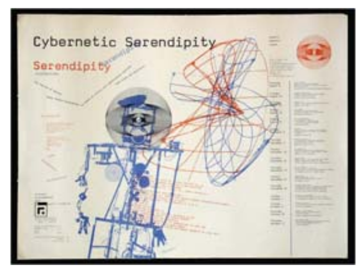


Fuller's complex of jitterbugs in the octa-/icosa-/cubocta-phase, 1948, 1976

Eureka is an exclamation used as an interjection to celebrate a discovery. It comes from ancient Greek "heureka" meaning approximately " I have found it". When Archimedes discovered that the volume of water displaced is equal to the volume of his body, he leaped out of the bathtub and rushed home naked crying "Eureka! eureka! What he found was the solution of a problem posed to him by Hiero of Syracuse, on how to find out the purity level of a golden crown. This anecdote first appeared in Vitruvius books on architecture. Serendipity comes from Serendip and is the old Arabic name for the island of Sri Lanka (former Ceylon) and means unexpected and fortunate discovery. It is the gift of striking upon or making fortunate discoveries when not in search of them. The expression was coined by the English writer Horace Walpole in 1751 in his novel "The three princes of serendip".[11].

In 1967 Frank Oppenheimer, visited the U.S. pavilion at the world's fair in Montreal. The great dome was Fuller's masterpiece, nicknamed the crystal palace or the Taj Mahal and he dedicated it to his wife. Oppenheimer visited the German pavilion and was absolutely fascinated to discover the 30 interactive "hands-on" stations of the "Erfahrungsfeld" by the German pedagogue and artist Hugo Kukelhaus (1900-1984). Kukelhaus was an antroposoph and Goetheist and his exhibitions had a strong influence on the learning environments in the sixties. [12]. This must have been Oppenheimer's "Eureka" to establish the Exploratorium in San Francisco two years later. (The Ontario science center also opened in the same year).

Fuller in front of his Montreal expo dome. Hugo Kukelhaus's "Erfahrungsfeld" was displayed in the German pavilion. 1967

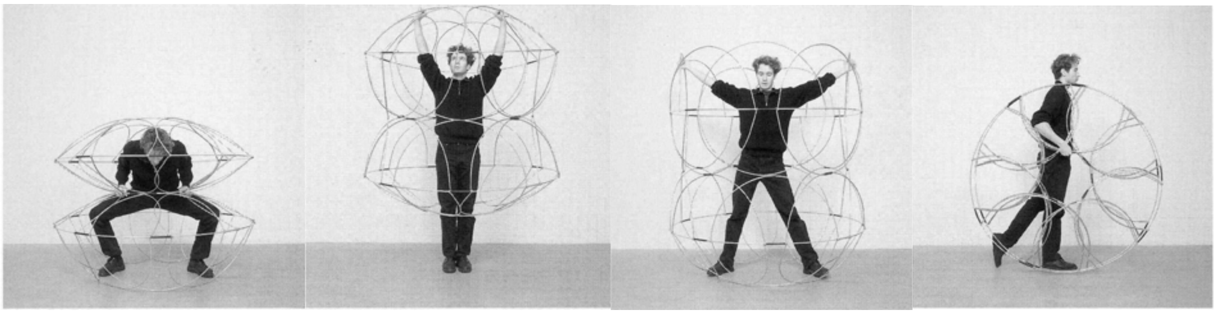


Frontispiece of the exhibition catalogue "cybernetic serendipity by Jasia Reichardt, London 1968

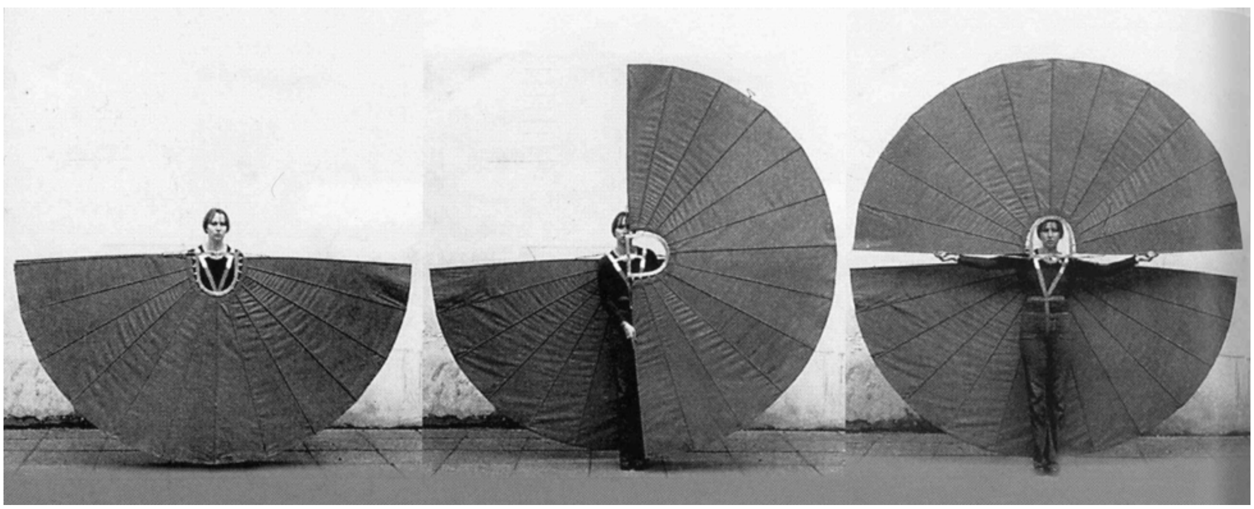
I myself have been involved in designing "hands-on" models for exhibitions and museums [13]. (Phaenomena 1984, Symmetry 1986, Aha gallery 1988, Circle 1990, Heureka 1991, Mathemagie 1993). In workshops and presentations I often used to present foldable models "hands-on" and named my performances "kinematic serendipity". The naming was a homage to the "cybernetic serendipity" exhibition of Jasia Reichardt, held in London 1968 [14]. This was a pioneer "hands-on" exhibition of interactive art and science. "Cybernetic serendipity" later toured the United States and the first station of display was in the Exploratorium in San Francisco when it opened its doors in 1969 [15].

Rudolf von Laban's dance in an icosahedron and Buckminster Fuller's performance of the jitterbug were outstanding "hands-on" exhibits, because both were interactive and involved our mind and body. The Swiss pedagogue Heinrich Pestalozzi (1746-1827) looked for the equilibrium between head, hand and heart. His student Friedrich Froebel (1782-1852) created "hands-on" blocks named after him (a sphere, cylinder and a cube). To play with "hands-on" models can induce an intuitive mood for "aha" experiences. Frank Lloyd Wright as well as Buckminster Fuller went to a Froebel Kindergarten. Fuller admired his great-aunt Margaret who was a transcendentalist and a fan of Johann Wolfgang Goethe [16].

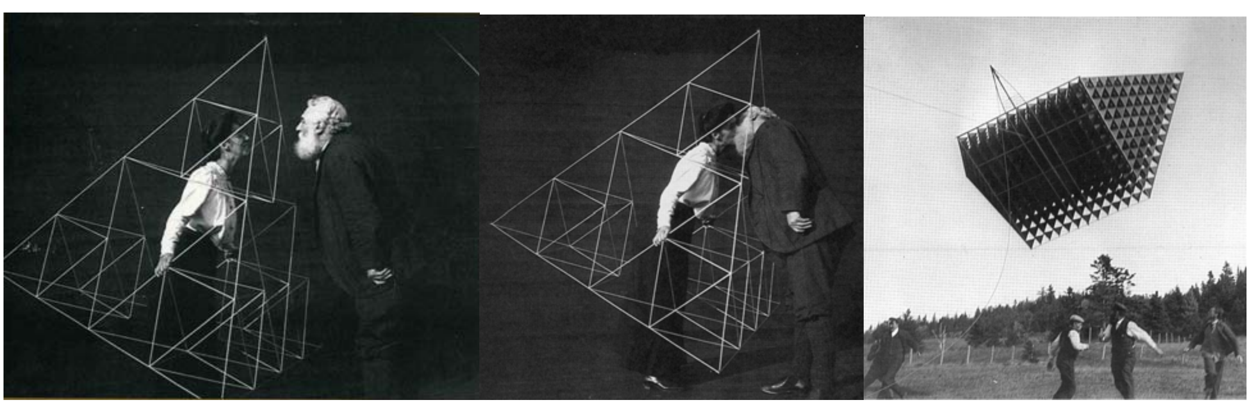
A kinetic model like the jitterbug has the interesting property that it changes from a shape with a rational periodic lattice into an icosahedral and therefore irrational enclosure (the golden mean or golden section). A new hands-on model of John Edmark (2010) depicts the Fibonacci pinecone, showing apparently the basic morphological principles as they occur in nature (the golden angle of 137.5 degrees). The 'squaring the circle', which is impossible with a ruler and compass on a flat sheet of paper, will be possible as a "hands-on" model with the help of the inversion, so to speak a "4-dimensional" process. The renowned drawing of the Vitruvian man by Leonardo da Vinci (1487), shows the human body perfectly placed into an irrational circle and as well into a rational square. Performances with a human size "hands-on" model can be like a "dance of many dimensions", unveiling interesting kinematic phenomena like translation and rotation, explosion and implosion, inversion and gastrulation, jitterbugging and tensegrity, knots and loops and Moebius strips.



"Taj Mahal's daughter" derived from the ancient Islamic culture of India. It captures the essence of the process known as cell division. A big sphere can be squeezed to form two smaller spheres as well as a great circle. [17]



"The black body fan" a performance of Rebecca Horn 1972. [18]



A heuristic approach of Alexander Graham Bell and his wife with his octet truss aluminum kite frames (1903) [19]
(note: Buckminster Fuller patented the same octet truss space frame system in 1961)

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