The Cosmogony of Bubble Diagrams

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Bubble diagrams are systems of lines and circles used in architecture to show relationships between functional areas of a program to develop an architectural plan. Appearing in many disciplines, they have been called "probably the most versatile and basic device for abstraction."' Although the instrument *par excellence* of functional planning, there is little scholarly examination of bubble diagrams. Yet, in their origins, there may be a richness that warrants closer scrutiny. This review traces the historic and continued use of bubble diagrams in practice and suggests alternative practices.

Bubble diagrams are rarely published with architectural projects, making their presence peculiarly invisible and their influence and diffusion difficult to trace. This lack of status either as the mythology of the profession or as artful corporeality of drawing condemns bubble diagrams to a practical procedure, beneath consideration of artist or historian, perpetuating the distinction between use and beauty and setting the ordinary outside the realm of investigation. Bubble diagrams do appear in handbooks for practicing architects and articles on design education. They were widely taught at schools of architecture at least from the 1940s through the 1970s when they were described as "integral to design education."[2] Bubble diagrams remain ubiquitous in architectural practice, although no longer enthusiastically taught at schools of architecture.' The seven editions of *Time-Saver Standards* from 1946 to 1990 provide an insight into their prevalence in practice. Since the publication is a collection of articles from many authors, primarily practicing architects, it provides a snapshot of practice during this time. Diagrams in the earlier editions were less abstract than those that followed. The oldest bubble diagrams in the publication are for a hospital and a school from 1939. Each subsequent edition has an increasing number of bubble diagrams. The present 1990 edition has at least 134 bubble diagrams.

The similar British publication, *Planning: The Architect's Handbook*, was first issued in 1936 with the most recent edition in 1985. Already by the 1947 edition, there were numerous "plan analysis diagrams" (at least 64) representing "fundamental relationships and circulations."[4] These diagrams seem more refined than their American counterparts.

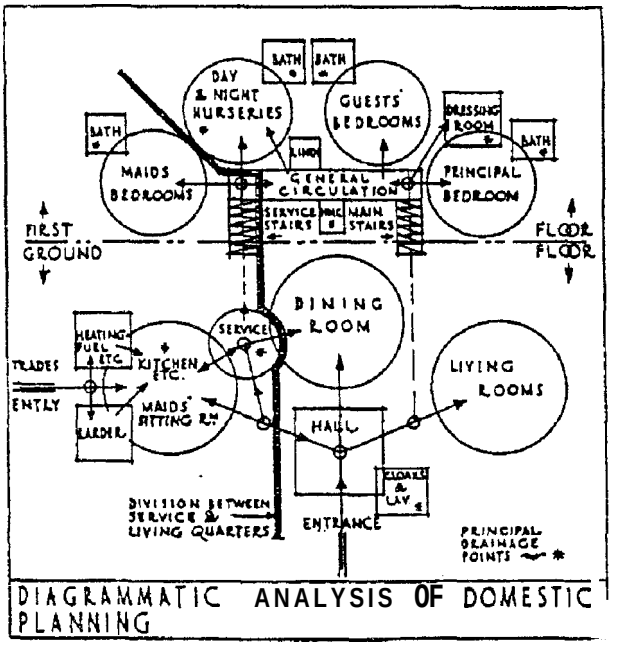

Fig. 1. E & O. *E., Planning: The Architect's Handbook, 1947.*

Two bubble diagrams published on design education suggest their importance to modem architecture is more than the lack of historical attention might imply. By 1930 at the Bauhaus, Hannes Meyer includes a bubble diagram for teaching the development of plans that relates to the design of housing. The document is titled "Factors determining a Plan" and has as its first consideration circulation issues. The names in the circles do not provide a standard list of rooms, they are instead conceptual, primarily pairs of opposed verbs such as "to arrive" and "to leave."

Le Corbusier's 1938 article, "If I had to teach you architecture," is a design primer including a bubble diagram. "You will begin by drawing a straight line, round which you will build up the necessary units in their proper order, each with the minimum area. Then on a sort of genealogical tree you work out their circulation, putting the appropriate units next to each other."[5] For Le Corbusier, the bubble diagram was

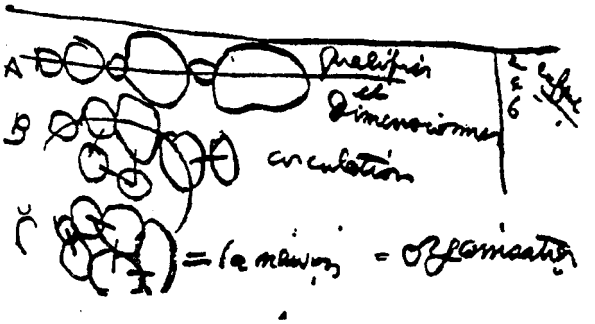

Fig. 2. Le Corbusier, *From the circulation and dimensional study comes the plan, 1938.*

part of a standard procedure by 1938.

The bubble diagram was probably not born with the modern movement but preceeded it in the beaux-arts emphasis on design from program. One year before Le Corbusier's article, a text explained essentially the same procedure with diagrams. Harbeson's 1926 Beaux-Arts student manual describes and illustrates the *esquisse* procedure of organizing the program-listed rooms to scale and "put down in a line in a sort of a diagram." The architectural bubble diagram may ultimately develop from eighteenth-century French natural history where Buffon adopted Linnaeus' description of the "geographic map" to illustrate multiple relations of the species, replacing the linear chain of being.[6] Architect Robert Kerr recommended a "thoroughfare plan" during design as early as 1864. It is a *"Skeleton* upon which rooms are grouped; the relation of rooms to each other being simply the relation of their doors," where the "routes of traffic" are highlighted and one should, "omit altogether the representation of the rooms." Kerr's diagram may be considered a plan abstraction dichotomizing function and access, making the diagram possible. The origins of modern bubble diagrams are thus much earlier than some design methods writers suggested, claiming their introduction as late as the 1960s.[7]

TOWARD A VISUAL HISTORY OF BUBBLE DIAGRAMS

Most writers suggest the origins of bubble diagrams are in set theory and symbolic logic. A visual history of bubble diagrams extends more widely, however, than a disciplinary view suggests. Three aspects are essential to the bubble diagram: (1) a network of lines describing relationships that connect (2) circles which contain (3) names.

Ramon Llull's (c. 1232-1316) *Ars Combinatoria* is credited as a first step toward modern computer science as it uses diagrams to generate all possible arrangements of a set of letters.[8] Llull received a sequence of life-changing visions that convinced him the remainder of his life should be dedicated to converting nonbelievers through a great book he was to write. Perplexed as to how Christian truth would persuade heathens, he ascended a mountain and "gazing intently heavenward, the Lord suddenly illuminated his mind, giving him the form and method for writing the book against

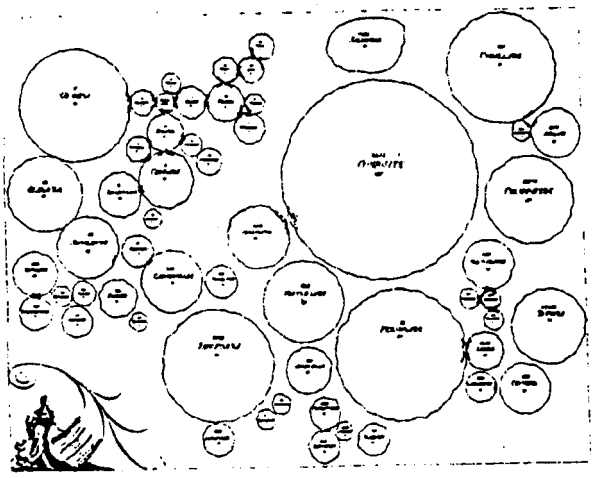

Fig. 3. Giseke after Linnaeus (1751), *Mappa genealogico-geographica affinitatum plantarum.*

the errors of the unbelievers." Thereafter known as "Doctor Illuminatus," Llull used diagrams as the "form and method" to demonstrate truth rather than appealing to scholastic authority for proof. The role of diagrams were "so that the senses can help the imagination, and the imagination the intellect."

Llull's *Great Universal Art* integrates the three key aspects of bubble diagrams in concentric circles. Llull's first diagram places letters in "chambers" around the circumference of a wheel for the nine attributes of God or "dignities." These chambers are joined by lines to establish all possible relationships. Reflecting the organization of the cosmos, the combinatory figures rotate to obtain all possible combinations of the letters for each chamber.

Llull's letter notation for the nine divine dignities introduces an "algebraic abstraction." These attributes or Names of God are considered the first causes because they diffuse themselves throughout all creation as real entities. In *The Hundred Names of God,* Llull asks, "since God has put virtues in words, plants and stones, how will He not have put far greater virtue into His names?" At the center of the *Ars Demonstrativa* wheel is the first (and tenth) letter, " A for God. The radiating lines leave an empty space for the "A," a visualization of negative theology. From the revolving circular figures, Llull derived tables of figures each with several letters. All possible combinations of the circular figure are recorded omitting repetitions which function very much like the affinity matrix used for modern bubble diagrams. An operator of the Lullian art can ascend the ladder of being all the way to the Trinity, making the book of nature a road to God.

While Llull was unique, argument through diagrams proliferated in the scholastic world at a time when letters were first used as an abstract ordering device. Simple diagrams long in use received detailed visual exegesis that were included in building iconography.[9] The concentric circle cosmos-diagram is manifest in Gothic cathedral rose windows,

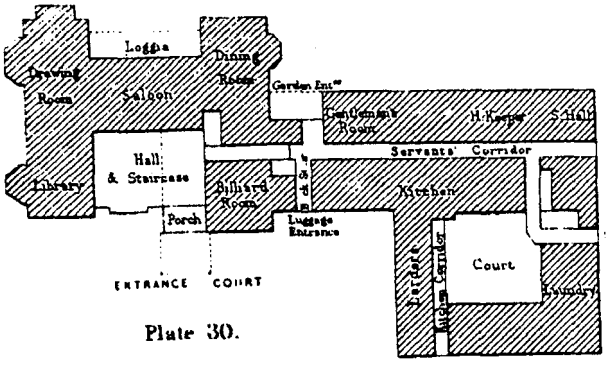

Fig. 4. Robert Kerr, *Thoroughfare* Plan, 1864.

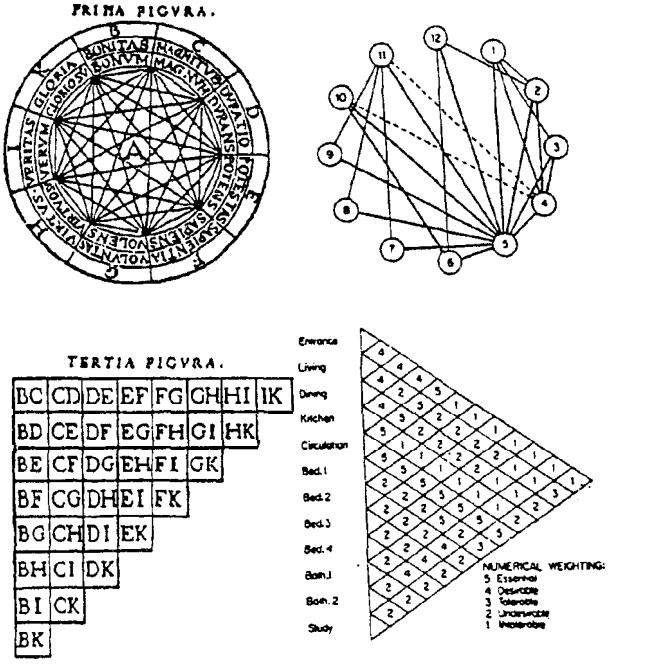

Fig. 5. Two Figures from Llull's *Ars Brevis* (Left), and modem diagrams, 1960 (Right).

wheels of fortune and floor labyrinths. The influence of the Llullian art in architecture has been traced to the design of the Escorial and via Giordano Bruno to the architecture of Scamozzi.[10] The buildings are inhabited Llullian rotae, mechanisms to draw down favorable dignities for their residents.

The Sephirotic tree of the Kabbalah, an important source for Llull, is another bubble diagram. Gershom Scholem explains that mysticism is possible only after accepting the idea of a great abyss between God and humanity with a search for a "hidden path to join them. *En-Sof,* the infinite and concealed God, like the Llullian "A," can only be described through negation. The outpouring of visible light from *En-Sof* through the Creator, "has a mystical shape which can be conveyed by images and names." The Godhead appears through attributes like Llull's dignities such as goodcess, severity and justice that are not metaphors but actually manifested in creation. The ten attributes or spheres called the Sefirothform adynamic unity, atree. In the thirteenth century the Sefiroth were developed into a theosophical system to describe the hidden process of divine life that is instrumental, where anyone with the correct formula could succeed in operating the "magical mechanism."

The Sefirotic tree provides a "mystical topography of the Divine realm."'' The ten emanations are a network, constituting a well-structured form, where every part or limb operates on the others. The Sefiroth are connected by means of secret "channels" or *tsinoroth,* radiating into each other. The upper and lower extremities of the channels are often shown open to reflect the light of *En-Sof,* the sap of the tree, passing through these openings as a seminal flux to germinate the world. The Sefirotic tree is the "skeleton of the universe," spreading its branches into the whole ofcreation. This primal Tree of Life, like the tree in the Garden of Eden, needs balance between opposites. Plucking a fruit isolates one of the Sefiroth, making the tree imbalanced and allowing evil to enter the world.

Stemmatic or tree diagrams were long in use in ancient Greece to organize textual ideas. Curiously, "stemma" meant not a tree but a circular wreath or garland. Roman noblemen displayed stemma in the house atrium to show their glorious descent from the gods. Descriptions suggest circular *imagines* were connected with painted *lineae* to form a pedigree. Roman law used the *Arbor Juris* to evaluate blood relations for succession rights and inheritance with circle and line diagrams. The Christian church adopted it as the *Arbor consanguinitatis* to bar marriages where blood relationships were too close on grounds of "affinity" (another name for bubble diagrams).[12] Tree diagrams flowered with architectonic details during the twelfth and thirteenth centuries when complex genealogical trees appeared.

As the totality forms a tree, the individual Sefirah, the ten circles, are its fruit. *Sefiroth* approximately translates as "spheres" or "regions." Although there are ten Sefiroth, the fundamental unity of God remains since ten was the number of totality; hence, Vitruvius' complete architectural text in ten books. As the body is an instrument of the soul, so the Sefiroth are instruments or vessels for God. Souls fly out from the Sefirotic tree as birds or fruit in circular form. Each of the Sefiroth appear in a wealth of symbolic representations with long lists of symbols for each Sefiroth. *Binah*, the third Sefiroth, signified among other things, differentiation. The point develops into a "palace" or "building" as the cosmos progressively unfolds from point to circle. The Sefiroth were sometimes referred to as human activities reflecting the order of the Godhead.

The ancient stemma as garland circling the head of ancestors, like the nimbus around the head, was aradiant soul. This radiating light is the fire of the life-soul (or genius) that was believed to reside in the head.[13] The Sephira or circles, sometimes formed of letters, can be understood as these souls, the astral body encased in a name.

The core of the Sefirotic tree are the names themselves. If

the circles are vessels, names are the divinity itself. All creation begins by God naming, not manipulating material, since it is creation out of nothing. At Creation, God endowed Adam with the ability to read the letters He impressed on things. Adam named all the animals by their spiritual essence, revealing their true character. This knowledge was dispersed after the fall, allowing us to receive only a small portion, divided into many languages.[14] The Ten Sefiroth, describing attributes of the Creator, are understood to combine into his name. The structure of the divine name anticipates all the elements of the world.

Today, names are believed to have no meaning, only pointing value.[15] Yet, names were widely believed to have an essential relationship to what they denote. Whoever had control over a name had the power of that thing. Greek amulets and magical papyri with drawings of human beings were covered with secret names. The true names of cities were kept secret for protection. Since the name is both part of the physical world (engraved in all things) and part of the spiritual world (breath), they were excellent vehicles for moving between the two realms. Divine names could be manipulated by mortals. Often it is the *name* of the deity, rather than the god itself, that was the real source of efficacy. Wind was a common form of soul and it was believed that vowels are "spirited" out of the lungs, such as Llull's "A."

Rites of receiving a new name create a new person or reincarnate an ancestor. Names received prior to birth, *pre-nom,* are a modern innovation. The tradition of name changing to create a new identity remains in modern culture, from professional wrestlers to Popes. Of course, the naming of buildings, the offspring of patron and architect, has a similar significance through the wish to project the future. In the Renaissance, great artists' visions appeared through their genius, a spirited pneuma, that could receive divine inspiration.[16] Andrea di Pietro became Palladio, an angel in an epic poem by Trissino, his sponsor and patron. Le Corbusier was a modern angelic artist who also took on a new identity.

The Ten Sefiroth are the "path of the names." The early *Sefer Yetzira* (Book of Creation) explained that the letters of the Hebrew alphabet are a foundation and provide directions to set them in a wall with 231 heavenly gates forming a wheel. The name is an instrument for the soul to join higher spirits. Written letters are physical, pronounced letters are spiritual, mental letters are intellectual and emanated letters are divine. *Unio mystica* (mystical union) occurs when the body liberates the ten Sefiroth engraved in the soul to ascend to the spiritual realm and cleave to the active intellect when all are in balance and "awesome mysteries were engraved in his heart." Cleaving to higher entities allows the human soul to change the mundane world. During an ascent, letters reportedly fly in the air.

Kabbalist theurgic activity could draw down divine powers into the mundane world. Words become instruments of creation. The sexual union of man and woman was also thought to draw down spirits. Procreatingis imitating at one's own level of existence the theogonic process. Two of the Sefiroth are known as bridegroom and the bride. The Sefiroth is a body of passage, a birth.

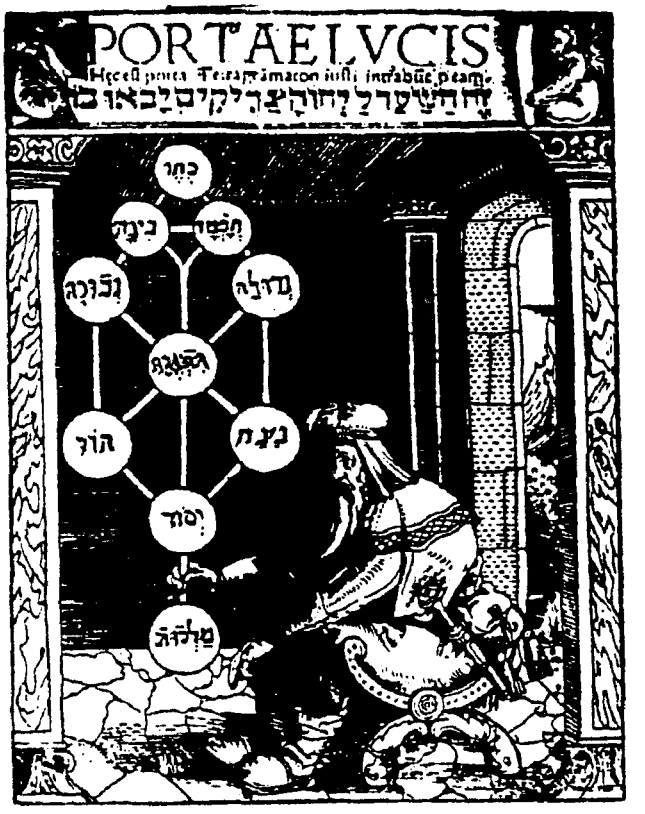

Fig. 6. Title page of *Portae Lucis,* 1516, The ten Sefiroth.

Diagrams assisted cleaving through mystical figures. The circle has long been a vehicle for visualization of the Godhead. Kabbalist mystic Abulfia inscribed letters in circles and had visions of circles. Llullian wheels may also have been meditation techniques. One codex recommends, "what this picture allows you to grasp with the bodily senses is that which you should bring forth spiritually." The exegetic doctrine of four levels of meaning (literal, moral, allegorical, mystical) allowed Kabbalist symbols to move between physical existence and mystical truth. They invited one to act rather than to contemplate, as divine forces were living entities that could be affected by human activity.

The influence of changing interpretations of Llull and the Kabbalah on later thinkers was substantial. In the last half of the nineteenth century, theosophy experienced a widespread revival through H. P. Blavatsky (1831-1891) and Rudolf Steiner (1861-1925). "The Jewish Sephirot Tree" (1924) was one of Steiner's chalkboard diagrams made during his Anthroposophy lectures. Steiner, designer of many buildings, was a proponent of a broad architectural functionalism. "Man can only experience true harmony of soul where what his soul knows to be its most valuable thoughts, feelings, and impulses are mirrored for his senses in the forms, colors, and so on of his surroundings." Theosophical influence on the arts

at this time is well known, particularly in the Bauhaus.[17] Hannes Meyer, author of an early modern bubble diagram, was an Anthroposophist for a time.

Like the diagrams, the name "bubble" has obscure origins. The multiplicity of names for bubble diagrams reflects as well as constructs their invisibility. "Bubble," referring to the diagrammatic circles, may derive from imitating the sound of bubbles forming, bursting or the lips making a bubble. "Bubble" describes things that are insubstantial. It may be this nascent, inform quality that makes "bubble" pertinent to the diagram itself. Bubbles are curiously tied to key sources of arguments for modern, "functional" architecture. Le Corbusier claimed "a building is like a soap bubble. This bubble is perfect and harmonious if the breath has been evenly distributed and regulated from the inside. The exterior is the result of an interior." Louis Sullivan invoked bubbles in his 1896 essay where he first introduced his often and easily misconstrued transcendental concept of "form follows function."

> Unceasingly the essence of things is taking shape in the matter of things, and this unspeakable process we call birth and growth. Awhile the spirit and the matter fade away together, and it is this that we call decadence, death. These two happenings seem jointed and interdependent, blended into one like a bubble and its iridescence, and they seem borne along upon a slowly moving air. This air is wonderful past all understanding.

According to Sullivan, function is apressure — an invisible force, the result of which is form.[18] One assumes that the pure form of the soap bubble elegantly and efficiently embodies the function that gives it shape, but both statements seem more focused on the breath or inspiration, for Le Corbusier that of the designer and for Sullivan, nature itself—a spiritus imaginus.

POSSIBLE FUTURE PRACTICES

The bubble diagram in its historical position can be understood to propose a transcendent view of the creative act, channeling creative forces to organize the true source of building, its active functions rooted in the mundane and rising with the soul. The circle of the bubble diagram, like the Sefiroth, is an inform soul awaiting embodiment, a receptive vessel. The name is a divination of the future, calling into nothingness the name of creation. The tree is not only a map without a terrain but an ascent, an imaginary voyage for the spirit of the designer. Like the Kabbalah, the bubble diagram can invite active contemplation to achieve a unity or balance in the physical world. Both systems are instrumental and begin their exegesis on the level of everyday activity. Bubble diagrams are an idealized perfection, pure function in procreative power, invisible, yet everywhere present.

The bubble diagram as practiced is subjected to two apparently incompatible critiques: First, that it is reductive, without formal attributes and second, that it merely becomes a plan without imaginative manipulation, simultaneously

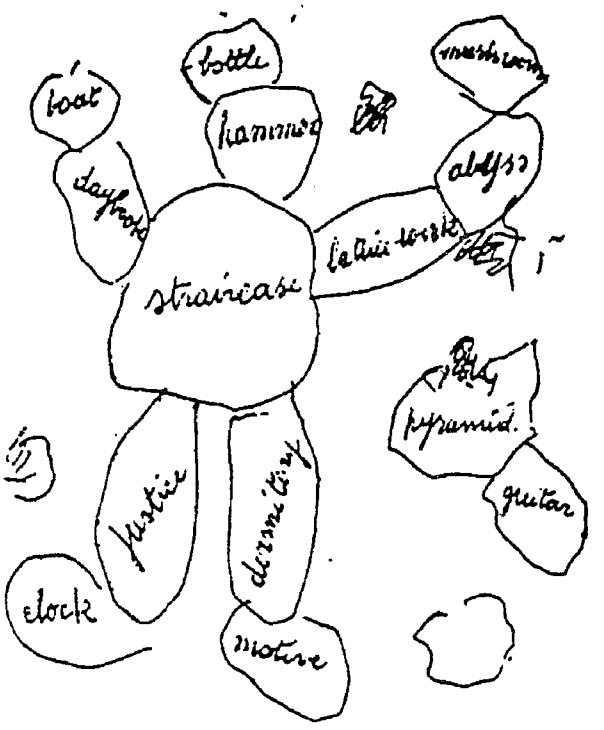

Fig. 7. Rene Magritte, untitled drawing.

formlessness and mere form. Since function is divorced from imagination, the procedure requires the external contribution of the architect's imagination. The diagram is not transformative but a device without generative power awaiting the external agency of imagination. Diagrams are presently considered reductive representations of the physical world. Traditional diagrams are not reductive, but essential, where one imaginatively enters into them and through the process of unfolding them creates a building design that is grounded in the cosmological view that the diagram represents.[19]

Bubble diagrams are most ineffective when the names are treated as a *pre-nom*, already fixed and not inviting speculation. Bubble diagrams at their best are a translation machine from word to embodiment, stimulating the frictional junctures between word and image, tempering a rush to form with oneric reverie. Deleuze and Guattari's critique of tree and wheel through rhizomes suggests that bubble diagrams could become internal invasive agents of the program.[20]

The mirror between microcosm and macrocosm has long been broken and any transcendence through the great chain of being is at best rhetorical. Although cosmological views have greatly changed, we can still use diagrams to reveal how everyday function always exceeds mere practicality. Rene Magritte produced a sign-painterly realism of ordinary objects.[21] His work evokes wonder by critically engaging the commonplace without ironic detachment. His naming, a surreal sur-nom, is productive because it not only provokes the question of translation, but sustains it, unresolved, in a slow engagement with the depths of similitude. Bubbles, like the sparking fire of Heraclitus, do not emanate from the heavens,

but float rhizomataically between realms with the otherworldly ordinariness of immanent transcendence. In this transfiguration of the commonplace, it is possible to imagine Lullian wheels of behavior settings spinning imaginal combinations such as an office tower reception room with a suspended porch swing. Le Corbusier used a dissection table in his dining room. A critical alternative practice with bubble diagrams can reveal the presence of invisible modern myths. The breath of function is not merely blowing bubbles, but inspiring the imagination.

NOTES

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[2] Richard Wesley, *The Search for Rational Form,* reprinted from *The Architecture Monograph,* Harvard Graduate School of Design, publication series in architecture, 1977, pp. 1-2. Geoffrey Broadbent, *Design in Architecture, Architecture and the Human Sciences.* (London: John Wiley, 1973), p. 260.

[3] For the most recent examples, see: American Institute of Architects, *The Architect's Handbook of Professional Practice, Volume two: The Project,* 1996. Donna Duerk, *Architectural Programming: Information Management for Design.* (New York: Van Nostrand, 1993). Robert Kumlin, *Architectural Programming.* (New York: McGraw-Hill, 1995).

[4] *Time-Saver Standards: A Manual of Essential Architectural Data.* The individual article authors are unnamed in early editions and claimed variously as "scores" (1966) and "hundreds"(1950, 1954), while the 1990 edition lists the names of about 120 "contributors." E. & O. E. (S. Rowland Pierce and Patrick Cutbush), *Planning: The Architect's Handbook.*(1950), p. 47.

[5] Le Corbusier, "If I had to teach you architecture." *Focus (London),* 1938, 3-12. Claude Schnaidt, *Hannes Meyer: Buildings, Projects and Writings,* (New York: Architectural Book, 1965) 42. Klaus Herdeg, *The Decorated Diagram: Harvard Architecture and the Failure of the Bauhaus Legacy,* (Cambridge: MIT Press, 1983), pp. 83-5.

[6] Percy Nobbs, *Design: A Treatise on the Discovery of Form.* (London: Oxford University Press, 1937), p. 255. John Harbeson, *The Study of Architectural Design with special reference to The Program of the Beaux-Arts Institute of Design.* (New York: Pencil Points Press, 1926), p. 78. Giulio Barsanti, "Buffon et l'image de lanature: de l'echelledes etres a lacartegeographique eta l'arbre genealogique." *Buffon 88.* Paris: J. Vrin, 1992), pp. 255-296.

[7] Robert Kerr, *The Gentleman's House.* (London: 1864), pp. 76, 467f. Geoffrey Broadbent, "A plain man's guide to systematic design methods." *Royal Institute of British Architects Journal,* 75 (May 1968), p. 223 and *Design in Architecture,* (1973), pp. 252f, 260.

[8] Raymon Llull, *Selected Works of Ramon Llull (1232-1316),* Two volumes, Edited and translated by Anthony Bonner, (Princeton: Princeton University Press, 1985). Frances Yates, *The Art of Memory,* (Chicago: University of Chicago Press, 1966).

[9] Ivan Illich, *In the Vineyard of the Text: A Commentary to Hugh's Didascalicon,* (Chicago: University of Chicago Press, 1993), p. 103f. Anna Esmeijer, *Divina Quartemitas: Aprelirninary study in the method and application of visual exegesis,* (Amsterdam: Van Gorcum Assen, 1978).

[10] Rene Taylor, "Architecture and Magic: Considerations on the *Idea* of the Escorial," *Essays in the History of Architecture Presented to Rudolf Wittkower,* editedby Douglas Fraser, Howard Hibbard and Milton Lewine (London: Phaidon, 1967). Marco Frascari, "A Secret Semiotic Skiagraphy: The Corporal Theatre of meanings in Vincenzo Scamozzi's Idea of Architecture," *Via: Architecture and Shadow,* 11 (1990), pp. 33-51.

[11] Gershom Scholem, *On the Kabbalah and its Symbolism,* translated by Ralph Manheim, (New York: Schocken, 1965), pp. 51-2. Gershom Scholem, *On the Mystical Shape of the Godhead,* Translated by Joachim Neugroschel, New York: Schocken, 1991. Moshe Idel, *Kabbalah: New Perspectives,* (New Haven: Yale University Press, 1988). For the Kabbalah's influence on Llull, Moshe Idel, "Ramon Lull and Ecstatic Kabbalah," *Journal of the Warburg and Courtauld Institutes,* 51 (1988). pp. 170-174.

[12] Arthur Watson, *The Early Iconography of the Tree of Jesse,* (London: Oxford University Press, 1934) 37-8. F. Saxl, "A Spiritual Encyclopedia of the Latter Middle Ages," *Journal of the Warburg and Courtauld Institutes,* 5 (1942) 82-142. Michael Evans, "The Geometry of the Mind," *AA Quarterly,* 12 (1980), pp. 32-55.

[13] Richard Broxton Onians, *The Origins of European Thought About the Body, the Mind, the Soul, the World, Time and Fate,* (Cambridge: Cambridge University Press, 1951), pp. 165-7, 441f.

[14] Ernst Cassirer, *Language and Myth,* translated by Susanne Langer, (New York: Dover, 1953), p. 45.

[15] Stephen Schwartz, *Naming, Necessity and Natural Kinds,* (Ithaca: Cornell University Press, 1977), p. 25.

[16] Muthesius describes the English love of naming houses even though numbers are more practical. Hermann Muthesius, *The English House,* translated by Janet Seligman, edited by Dennis Sharp (New York: Rizzoli, 1979), p. 7. Dominic Cullinan, "Calling them Names," *Scroope: Cambridge Architectural Journal,* 8 (1996-97), pp. 12-14. David Summers, *The Judgement of Sense: Renaissance Naturalism and the Rise of Aesthetics,* (Cambridge: Cambridge University Press, 1987).

[17] Rudolf Steiner, *Tafelzeichnungen Entwurfe Architectur,* (Stuttgart: Tertium, 1994), p. 75. David Adams, "Rudolf Steiner's First Goetheanum as an Illustration of Organic Functionalism." *Journal of the Society of Architectural Historians,* 51 (June 1992) 182-204. Joseph Rykwert, "The Dark Side of the Bauhaus," *The Necessity of Artijice: Ideas in Architecture,* (New York: Rizzoli, 1982), pp. 44-49.

[18] Louis Sullivan, *Kindergarten Chats and Other Writings,* (New York: Dover, 1979), pp. 208, 48. Le Corbusier, *Towards a new Architecture,* (New York: Dover, 1986), p. 181.

[19] Douglas Graf, "Diagrams." *Perspecta 22: The Journal of the Yale School of Architecture, Paradigms of Architecture* (New York: Rizolli, 1986) 43. Forewords, *Time-Saver Standards: A Manual of Essential Architectural Data.* Giuseppe Tucci, *The Theory and Practice of the Mandala* (London: Rider, 1969). Joseph Rykwert, *The Idea of a Town,* (Cambridge: MIT Press, 1988).

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