Probable Geometries:

The Architecture of Writing in Bodies

In the last decade the attention of architectural designers and theorists has been primarily directed toward the descriptive geometries with which architectural space is written. To the extent that geometry is the preferred language for architectural communication, its interrogation has become the dominant form of writing in architecture. More precisely, the majority of both spatial and theoretical innovations in architecture have become increasingly dependent on geometric conflicts. These developments are superlatively described by Mark Wigley in his introduction to the Deconstructivist Architecture exhibition and publication as a conflict within and between forms.' Wigley's essay on architectural form depends on the belief that geometric conflict presents a new form of writing. Architecture's recent investment in geometric conflicts can be seen as an internal response to the critique, by philosophy, that writing is essentially an "antiarchitectural gesture" defined against geometric purity. The interest in formal conflict positions Wigley and others on a common trajectory inaugurated by Robert Venturi with the publication of Complexity and Contradiction in Architecture in 1966.[1] Of the many similarities and significant differences between these theorists of formal conflict, the most important suggests that the now dominant practice of eliding cultural difference with formal conflict as a method for writing in architecture is becoming progressively suspect. Yet the exclusion of architecture from writing persists, demanding a further interrogation of geometry. If indeed geometric conflict is becoming bankrupt as an urban organizational model, what are the alternatives to the transgression of geometric order available to archi-

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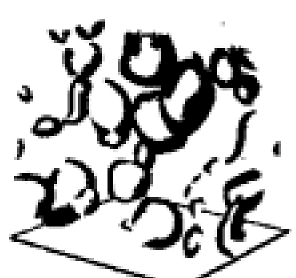
tecture? First, an adequate definition of a practice of writing in architecture must be formulated, one capable of engendering the urban, cultural, and programmatic differences that have been previously exploited for their ability to generate geometric conflicts and contradictions.

Architecture is described by philosopher Denis Hollier in Against Architecture as the discipline that resists the play of writing more than any other. Hollier opposes the ideal proportions of architectural order to the indeterminate, heterogeneous, and undecidable characteristics of *"writing"* as practiced by philosopher Georges Bataille.

"Writing in this sense would be a profoundly antiarchitectural gesture, a nonconstructive gesture, one that, on the contrary, undermines and destroys everything whose existence depends on edifying pretensions .... We propose to read Bataille here starting from this refusal, a refusal that produces the heterogeneity, in contrast to the continuity pursued by discourse as its ideal, that will be indicated by the term writing."[3]

For Hollier, architecture's resistance to writing arises from two linked ideas inherent in any logic of proportion: the whole organism and exact measure. Hollier confirms that these two components of architectural proportion underwrite static, fixed forms in that *"the greatest motive for Botaille's aggressivity toward architecture is its anthropomorphism."*[4] Bataille locates in geometric proportion an anthropomorphism that is in essence architectural.

1. Shell structure aggregations of matter.



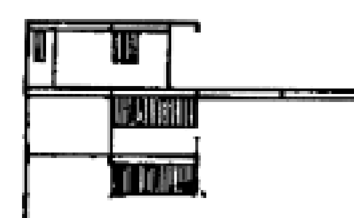
"It is obvious, moreover, that mathematical organization imposed on stone is none other than the completion o f an evolution o f earthly forms, whose meaning is given, in the biological order, by the passage of the simian to the human form, the latter already presenting all the elements of architecture. In morphological progress men apparently represent only an intermediate stage between monkeys and great edifices. Forms have become more and more static, more and more dominant. The human order from the beginning is, just as easily, bound up with architectural order, which is no more than its development"[5]

The mathematics that underwrites such an exact classical geometry is impartial: no number is more or less ideal than any other. In response to that dilemma, architecture has historically identified pure forms that can be made to correlate with ideal bodies through symmetry and proportion. The moments where geometric exactitude is most vital to architecture are the instances where buildings are described as ideal, whole, complete, autonomous, and unified bodies. This tradition began with Vitruvius's description of proportion and symmetry in *"Book III"* of the Ten Books of Architecture.

"Proportion is a correspondence among the measures o f the members o f an entire work, and o f *the whole to a certain part selected as standard. From this result the prin ciples of symmetry. Without symmetry and proportion there can be no principles in the design o f any temple; that is, i f there is no precise relation between its members, as in the case of a well shaped man."*[6]

2. Le Corbusier's Maison Dom-ino typology.

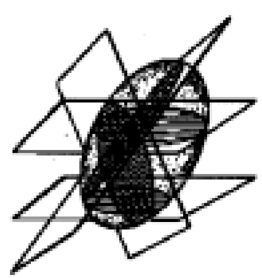
3. Le Corbusier's Maison Citrohan typology.



Since that time, the logic of the whole organism has been linked with the complete, pure forms of exact geometries in architecture. The static proportions of these forms are rejected by Bataille and Hollier in favor of a transgressive practice of writing against form.

As writing is indeterminate, nonideal, heterogeneous, and undecidable, it is implicitly resisted by exact geometries. Exact geometries may render only those characteristics that can be reduced to ideal proportions. They promise a universally translatable and therefore absolutely fixed language for architecture, as their pure forms are written *"once and for all."* For instance, there is only one sphere for all cultures for all time: an infinite number of points on a shared surface equidistant from a single radius point. Ideal forms such as these must be reducible to eidetic mathematical statements. Eidetic forms are (I) exact in measure and contour, (2) visually fixed, and (3) identically repeatable. Architecture, as described by Bataille and Hollier, is eidetic: it is reducible, static, exact, fixed, proportional, and identically reproducible. This monumental characterization of architecture through its geometric conventions allows for the dialectical opposition of decidable geometric bodies and undecidable bodily matter. Hollier and Bataille are predominantly interested in architecture as a discipline against which writing can be defined. For their philosophy, architecture is refused as an ideal style of discourse constructed of arrested, static, complete forms against which writing stands. The best definition of writing that Bataille and Hollier can provide is that it is defined Against Architecture. The anti-architectural practice of writing does not arrest matter in fixed proportions; it respects and maintains

4. Random sections.



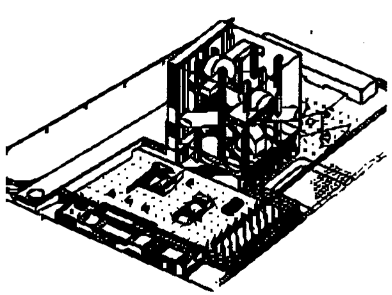
incompletness, undecidability, amorphousness, and other vague characteristics. Therefore, any writing in architecture must begin with a geometry that does not reduce matter to ideal forms. Geometries that not only maintain but measure amorphousness in some form resist the definition of writing against architecture. Recently themes of writing in architecture have engendered an anti-architectural, transgressive bias for formal juxtapositions, collisions, fragmentations,and contradictions. The measurement and description of amorphous, fluid, flexible, open, non-ideal, non-eidetic, provisional, incomplete, indefinite, and irreducible effects is an alternative to the mere arrest of these qualities in conflicting forms. In *"The Mechanics* of *Fluids,"* Luce Irigaray points to a distinct lack of attention to the description of vital matter and fluids in the sciences and mathematics, as the exact measure of these kinds of matter is precluded by their mobility, fluidity, and mutability.[7] Bataille's proclivity for *"base matter"* along with his rejection of pure forms explains his definition of writing as an anti-architectural gesture; the exact, proportional, fixed, and static geometries, seemingly natural to architecture, are incapable of describing corporeal matter and its undecidable effects. This rejection may be taken as an invitation: rather than violating the inadequate stasis of exact geometries, writing in architecture must begin with an adequate description of amorphous matter through *"anexact yet rigorous"* geometries.

Since the publication of Edmund Husserl's Origin of Geometry in 1917 there has been considerable philosophical speculation surrounding the definition of anexact forms. Jacques Derrida and Gilles Deleuze and Félix Guattari in A Thousand Plateaus have articulated the characteristics of various proto-geometries that are

5. Sectioning randomly oriented objects with a single plane.

neither exact nor inexact but "anexact yet rigorous."[8] Without rehearsing the extensive philosophical discourse surrounding the development of the term **anexact** it is possible to describe its operative characteristics briefly. The distinctions between exact, inexact, and anexact geometries, although seemingly esoteric, are becoming critical to any discussion of new spatial organizations. Husserl distinguishes exact forms as those that can be reduced eidetically. Like the form of a sphere, they are not only precise but can be reduced completely. Conversely, inexact forms are described as those figures that cannot be fixed or reduced because their contours cannot be described. In interrogating Husserlian exact geometries, Irigaray, Derrida, and Deleuze locate in many of the "vague essences" of science both a measurable rigor and a resistance to ideal reduction. These "anexact yet rigorous" forms can be described with local precision yet cannot be wholly reduced. These irreducible but precise geometries are typically associated with disciplines that are forced to develop models that must remain incomplete. For example, the geologic sciences of the earth cannot develop a single fixed model for the continuous transformation of matter. Therefore geologists employ what Husserl has referred to as "anexact proto-geometries" Protogeometries are used to measure various contours before they are reduced to eidetic statements. These descriptions are rigorous, yet many resist being reduced to exact forms and are referred to as anexact. These proto-geometries are employed to describe local effects with a clarity not possible in alternative global systems, which would reduce these effects to inexactitudes. These descriptions are rigorous and precise (they are not inexact) yet lack unity and completion (they are not totalizing). Disciplines dedicated to the study of vital

6. OMA, Bibliotheque de France, axonometric, 1989.

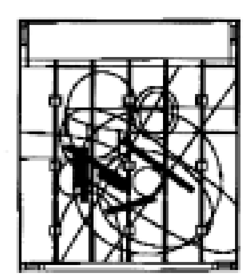


matter (embryology, virology, biology, and geology to name a few) have recently been the first to develop convincing geometric descriptions of vague forms Most importantly, the development of stochastic and probable geometries by these disciplines indicates that all geometries are not exact. The ability for these anexact systems to measure undecidable, mobile, and fluid behaviors without arresting their effects in reduced, fixed forms describes an open practice of writing that exists within the horizon of geometric rigor.

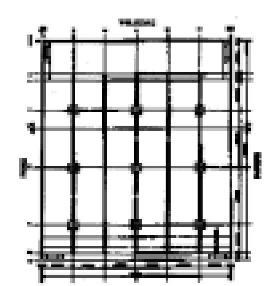
As a consequence of recent biomedical image-processing technologies, biometrics, the measurement of biological objects, has recently developed the ability to accurately measure shapes and shape changes. Analyses of biometric shape changes typically employ irreducible, supple, deformable geometries to describe the incorporation of unpredicted external forces in the continuous morphogenetic development of form. The probable geometry of the biometric "random section" model will provide a specific example of supple measurement that already exists as an architectural device. As this essay focuses on only one of a manifold collection of techniques, I would suggest for further reading not only the canonic works of D'Arcy Thompson and Rene Thom but also Fred Bookstein's The Measurement of Biological Shape and Shape Changee, which provide an extensive description of various other anexact and diffeomorphic geometries and their applications to organic matter. [9]

A case study of the random section model of probable geometry will provide architecture with the possibility of writing volumetric indeterminacy within a

7. OMA, Bibliothèque de France, superposition of public space.



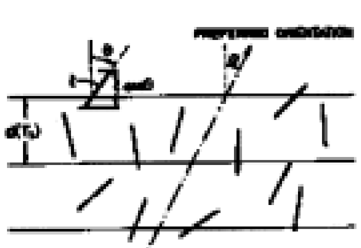
8. OMA, Bibliothèque de France, diagram of wall structure.



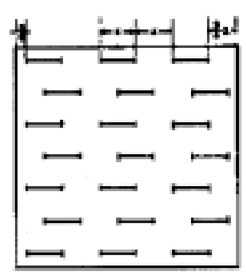
precise and rigorous system of measurement: a system of serial transections along with related coefficients of size, shape, and orientation. In architecture this particular model first came to my attention in an essay by Kas Oosterhuis, adjacent to a seemingly unrelated series of Oscar Niemeyer sketches.[10] The use of this scientific diagram by an architect, in close proximity to Niemeyer's sketches, suggested a latent connection between orthographic rigor and amorphous organic forms. Upon further research I found that this system shared with architecture a practice of stereometric projection: as stereology (a term first developed by Hans Elias in 1961) is "*the study of three-dimensional structures of specimens by examination of various two-dimensional images, usually o f sections through it*"[11] The difference between the orthographic techniques of architecture (which provide two-dimensional anterior descriptions of objects before their construction) and two-dimensional histological descriptions of the human body (which provide ex post facto two-dimensional measurements of shape and size to existing matter), is that architecture prefers to begin with ideal forms whereas materials science, food science, geology, astronomy, and the life sciences begin with the amorphous. A close examination of one of these probable or stochastic geometric models reveals that architecture's predilection for eidetic, exact forms precludes the description of flexible, fluid, or mutable programs and spaces.

It is important to observe that these probable geometries occupy a provisional relationship to the matter they describe; they do not embody or symbolize anything. Geometry has classically occupied a foundational position in architecture,

9. Buffon's Needle Problem.



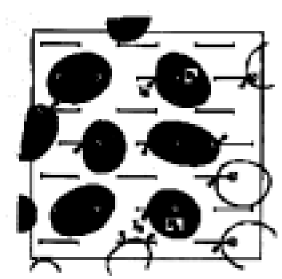
10. Chalkley and Weibel's multipurpose test grid.



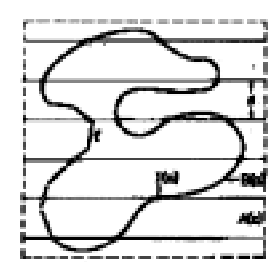
and this tradition must certainly be overcome in order to exploit the effects of geometric probability. Architecture's orthographic plan and section projections are identical to the parallel serial transections employed in probable geometry, yet in the study of matter the events described between these sections are variable, indeterminate, and not reducible to ideal forms. Perhaps the first attempt by an architect to develop a provisional system of geometric transections to describe the unrelated contours of spatial, structural, and programmatic contents was by Le Corbusier in the 1920s. In the serial parallel plan cuts of the Maison Dom-ino and the serial parallel section cuts of the Maison Citrohan, Le Corbusier attempted to develop structural and geometric systems that would be completely independent of the organization and functions of the buildings. In the biological practices of stereology these provisional cuts are referred to as "random sections."

The geometric principle of Le Corbusier's Maison Citrohan is a series of parallel lateral sections. These lateral load-bearing walls allow for greater freedom in openings since they eliminate fixed columns and beams. Accompanying this freedom in penetrating the walls is the ability to place the floor slabs at virtually any level and slope. Inter-sectional volumetric possibilities multiply as the necessity for fixed columns and beams is removed by these lateral parallel walls. The provisional deployment of rigid parallel transections increases the possible orientation, shape, and size of internal volumes. The planimetric freedom of the Domino and the sectional freedom of the Citrohan multiply the structural and pro-

11. Estimating the volume to surface ratio from a point and intersection count.



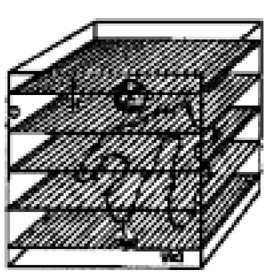
12. Estimation of curve length from the number of intersections with a grid of parallel lines.



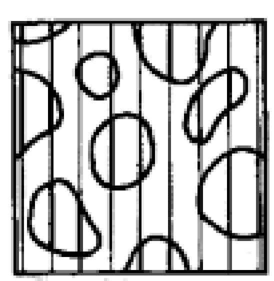
grammatic possibilities and combinations within the house. Le Corbusier revolutionized the architectural plane by arguing that it supported only one moment of the contiguous space that passed through it. Previously, architecture strove to represent all essential spatial characteristics on a transcendent, reduced plane. Erwin Panofsky, in the chapter *"History of the Theory of Human Proportions as a Reflection of the History of Styles"* in Meaning in the Visual Arts, poignantly describes this architectonic logic: *"Egyptian representations are planar because Egyptian art renders only that which can de facto be presented in the plane; . . . the Egyptians positively excluded the three-quarter profile and oblique directions o f the torso or limbs."*[12] Where Panofsky's reduced *"geometrical plan"* conveys information *"incompletely yet in one image,"* Le Corbusier suggests an incompleteness that proliferates between images. In the Citrohan and Dom-ino types the two-dimensional intersections with the parallel walls are fixed while the spaces between those contours can only be described with probability. The flexibility and adaptability of structure and program in the Citrohan and Dom-ino organizations are intricately connected to this geometry of sectional regulation and inter-sectional probability. The urban, political, structural, programmatic, and spatial effects of the extension of the principles of the random section and random plan since their invention by Le Corbusier are suggested by the library projects of Rem Koolhaas.

The development of the random section model, as it is known now in biometric science, originated with the development of the 'Needle Problem' by the celebrated naturalist Comte de Buffon in 1777.[13] The Needle Problem is a geomet-

13. Intersection of a space curve by planes.



14. Linear analysis.

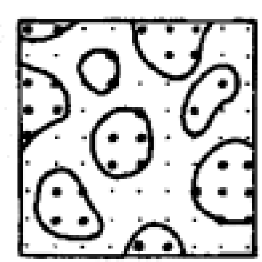


ric model used to describe the probability of chance events. As the Citrohan and Dom-ino types multiplied the possibilities for programmatic and volumetric events between lateral walls, Buffon's Needle Problem describes a multiplicity of probable occurrences without reducing them to any single rule.

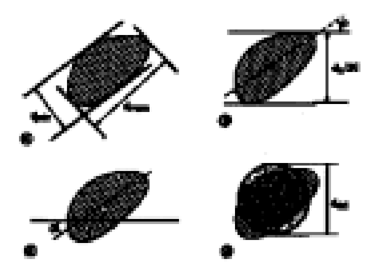
Probability theory is typically attributed to the mathematicians Blaise Pascal (1623-62) and Peirre de Fermat (1601-65). But Jackob Bernoulli was the first to publish a treatise on probability theory in 1713, in which he described two types of **probability, discrete and continuous.** An example of discrete probability is the toss of a coin, whose symmetry permits one to state in advance that it will always land on one of two sides. Continuous systems, due to configurations of shape, may not state the possible positions of an object in advance. Therefore, an experimental series must be performed to establish the frequency of possible positions. With the assistance of a professional gambler, Buffon developed a twodimensional model of continuous probability capable of describing the occurrence of a needle intersecting a parallel series of lines when thrown on a horizontal surface. Given a striped surface with a consistent band width (d) and a needle length (L) dropped at random onto the surface, the probability that the needle will intersect the boundary is 2L/?d. This geometric technique was revised by Ewald Weibel in 1966 in the form of the Multipurpose Test Grid.[14]

In 1847, Buffon's Needle Problem was adapted by French geologist Achille Delesse for the analyses of the volume areas of minerals in rock samples.[15] Delesse's Principle states that the volume fraction of a component tissue can be estimated

15. Point analysis.



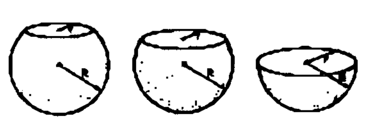
16. Diameter of the area of an equivalent circle by the random caliper diameter method.



by measuring the area fraction of a random section occupied by that volume's transection. The Principle of Delesse demonstrates that the areas occupied by different components in a single section approximate closely the ratios between the volumes occupied by those components in three-dimensional space. The Principle allows an estimation of volume from the area analysis of random transections. With this technique Delesse was able to polish a single surface and estimate the internal mineral content of specific specimens. In 1898 Rosiwal adapted Delesse's principles to Buffon's linear analysis and used it as a transectional device. The profiile areas in two dimensions are estimated from the proportion of objects lying on the test grid. In the following linear example, the total length of intersection with these lines is 25 percent of the total length of the test lines. According to the Principle of Delesse, the area volume of these objects is then .25 +- .024 of the total volume. A test grid of points can also be used, as proven by Nil Aleksandro Glagolev in 1933, where, for instance, a grid of 81 points cutting a section through nine objects with a total of 36 intersections yields: 81 / (9 x 36) = 0.25. It is only recently that these geological techniques were employed by biologists (primarily Weibel, Elias, and Underwood) for the reconstruction of actual shape rather than mere statistical area. The plane contour analysis of Buffon, along with the projection of this information into three dimensions using the Delesse Principle, has recently been applied to the serial transections of biological description, such as vivisection, CaT, PET, and X-ray imaging. [16]

Histology and all other biological descriptions have been plagued by two linked problems: the human body conceals its contents within an opaque and fragile

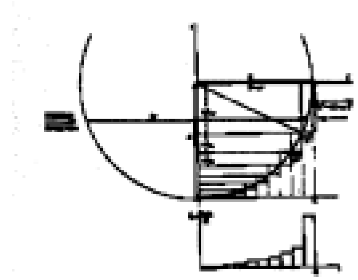
17. Profile radius "r" depends on the level at which each sphere is sectioned.



interior, and the dimensional integrity of its size and shape is contingent upon the fluidities, movements, and pressures of living in time. Stereometry attempts to describe the shape, size, area, and volume of organs in a manner that is indirect, rapid, flexible, versatile, and *"founded upon ideas and procedures drawn from geometric probability"* in order to describe the fluidity of dynamic bodies prone to geometric instability and deformation. As Weibel states: *"The tissues* of *biologic organisms are built of solid structures, three-dimensional bodies which are characterized by a certain volume, a surface area and some geometric properties which are often difficult to define in precise terms."*[17] It is the resistance of biological structures to geometric exactitude that determined *"how two such apparently disparate subjects as geometry and probability came to be associated."* In the description of the area diameter of a transection of muscle fiber, for instance, the shape is *"more or less"* circular but cannot be reduced to an actual circle. The transection's roundness results from the fluctuations of shape due to adjacent pressures, distension, and the compression of outside forces on the body. These contingent pressures that deform the fiber are more important than any reduction to a pure eidetic form. Stereometric serial transections, as developed by Buffon and Delesse, have in the last two decades been adapted, with the addition of coefficients for the recon-struction of shape, to maintain deformations, particularities, and differences as the registration of meaningful events.

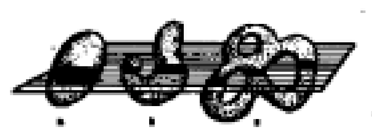
The simplest coefficients of shape are used to determine the degrees of randomness in shape and orientation of volumes. Any collection of randomly oriented

18. Frequency distribution of the various profile sizes based on the level of sectioning.



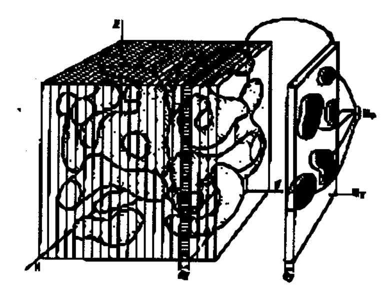
spheres, when sectioned, will yield circles of varying sizes. A coefficient of shape based on the number of sectional elements and their mean diameter is used to determine whether or not the varying circles result from similarly or randomly sized spheres. Thickened lines, ellipses, and circles indicate the presence of more or less cylindrical strands of varying orientations, such as those of the large and small intestines. The reconstruction of the orientation and continuities of these loops as they pass randomly through the transections is vital, and coefficients for tubular volumes have been developed to model these relationships with high degrees of probability. From the areas and shapes of these sectioned lines, ellipses, and circles as they appear in two or more transections, the length, diameter, orientation, and quantity of tubular elements can be described. Unlike architecture - which is more or less anistropic, or regularly structured and aligned to an orthogonal descriptive grid (conventionally the surfaces of buildings correspond exactly to the drawn planes of orthogonal projection) - in cases of anistropic linear tissue, stereometry achieves greater accuracy by maximizing the random alignment of cutting planes or probing points. Moreover, the degree of accuracy of these sections relates to their randomness. In anistropic tissues, where matter is organized in nonrandom recursive patterns, a higher degree of accuracy is achieved as the orientation of the random section differs from that of the tissue itself. Anistropic tissues display different characteristics in different axes and assume different positions in response to external stimuli. A system of rotational coefficients has already been developed to locate the most random orientations for these sections. Random section analyses exploit the obliqueness and particularities of organs, in reference to parallel transections and orthogonal grids.

19. Convex, non-convex and topological elements yielding circles.



The case study of the probable geometry of Buffon, Delesse, and Weibel, among others, moves architecture's fixed orthogonality through the disciplines of professional gambling, geology, and biology and closer to the behavior of vital matter while retaining a rigorous system of measure. In these stereometric examples, possible three-dimensional areas and shapes are projected from two-dimensional transections through a radical orthogonal technique that seems to be already natural to architecture. These indeterminate forms are not fixed, although they are are written between known contours. The elision of geometry with probability, along with the provisional, rather than essential alignment of these systems to matter, allows varying degrees of amorphousness to be measured between local exactitudes. The possibilities of this random section technique were explored by Le Corbusier in his Citrohan and Dom-ino types and extended by Koolhaas in his recent library competition projects. Anexact geometries such as these may supply architecture with the ability to measure amorphousness and undecidability in a manner conventionally associated with writing rather than architecture.

20. Tubular anistropic elements.



endnotes

I.MarkWigley; 'DeconstructivistArchitecture:' in Mark Wigley and Philip Johnson, Deconstructivist Architecture (New York, 1988), 10-20.

2. Robert Venturi, Complexity and Contradiction in Architecture (NewYork, 1966).

3. Denis Hollier, Against Architecture: The Writings of Georges Bataille, trans. Betsy Wing (Cambridge, Mass., 1989) 23.

4. Denis Hollier, Against Architecture.

5. Georges Bataille,"Architecture," Documents 2 (May 1929):171-72.

6. Vitruvius, The Ten Books of Architecture, trans. Morris Hickey Morgan (NewYork, 1960).

7. Luce Irigaray. This Sex Which Is Not One, trans. Catherine Porter with Carolyn Burke (Ithaca, N.Y., 1985).

8. See Jacques Derrida, Edmund Husserl's Orign ~ of Geometry: An Introduction, trans. by John P Leavey, Jr. (Lincoln, Nebraska, 1989) and Gilles Deleuze and Felix Guattari, A Thousand Plateaus Capitalism and Schizophrenia, Brian Massumi (Minneapolis, 1987).

9. Fred Bookstein, The Measurement of Biological Shape and Shape Change (Berlin and NewYork, 1978).

10. Kas Oosterhuis,"Space,Time,Volume:' Wiederhall I 2 (1990):5-8.

I I. Ewald R. Weibel and Hans Elias, Quantitative Methods in Morphology (Berlin, 1967).

12. Erwin Panofsky, Meaning in the Visual Arts (Chicago, 955).

13. See Geometrical Probability and Biological Structures: Buffon's 200th Anniversary: Proceedings, ed. R. E. Miles and J. Serra (Berlin and New York, 1978).

14. For a discussion of the technique of the random section model see E. R. Weibel, G. S. Kistler and W R. Scherle, "Practical Stereological Methods for Morphometric Cytology," Journal of Cellular Biology (July, 1966):23-38. For related discussions of the applications of the random section model, see John C. Russ, Practical StereoloQV (NewYork, 1986) and P N. Gaunt and WA. Gaunt, Three Dimensional Reconstruction in Biology (Baltimore, 1978).

I5.Achille Delesse, Proc6d6 M6canique pour d6terminer la Composition des Roches (Paris, 1847).

16. For applications of these techniques to contemporary bio-medical imaging see Barbara Maria Stafford, Imaging the Body From Fragment to Total Display (Chicago, 1992).

17.Weibel and Elias, Morphology.

21. Variable profile sections of an irregular solid.