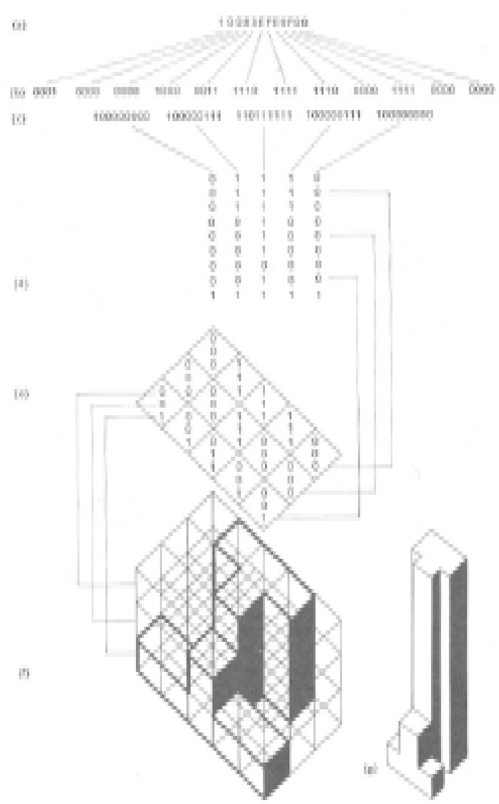
$10_2 83EFE0F0_2$ or the Seagram Building

SEAN KELLER
Harvard University

Like a strange organic molecule, the formula of the Seagram Building was discovered by Lionel March at the University of Cambridge in 1973 (figs. 1 and 2). Removed from its famous site, stripped of its materiality, and pinned to a cubic grid, Mies's iconic work was distilled finally into a single number "about the same length as some telephone dialing codes": $10_2 83EFE0F0_2$. Similarly, Le Corbusier's Maison Minimum—apparently not compact enough—became F2803F71280EFE032F (fig. 3). These "boolean descriptions" appeared in an article describing the mathematical basis of computer modeling.[1] Still uncommon and arcane, computers were central to March's effort as head of Cambridge's Center for Land Use and Built Form Study to direct architectural education and practice away from what he considered an unhealthy obsession with appearances, and toward the scientific solution of social and environmental problems.

Figure 1: Boolean description of the Seagram Building, Lionel March, 1976.



Yet even March could not resist demonstrating the novel formal potential of his mathematics: by tweaking a few numbers one could easily produce a beveled version of the Seagram Building (fig. 4). His colleague Robin Forrest used the same technique to create alternatives which were rotated, scaled and sheared (fig. 5). For the first time in architectural history such transformational opera-

Figure 2: Seagram Building, New York, Ludwig Mies van der Rohe, 1957.

Figure 3: Boolean description of Le Corbusier's Maison Minimum plan, March, 1976.

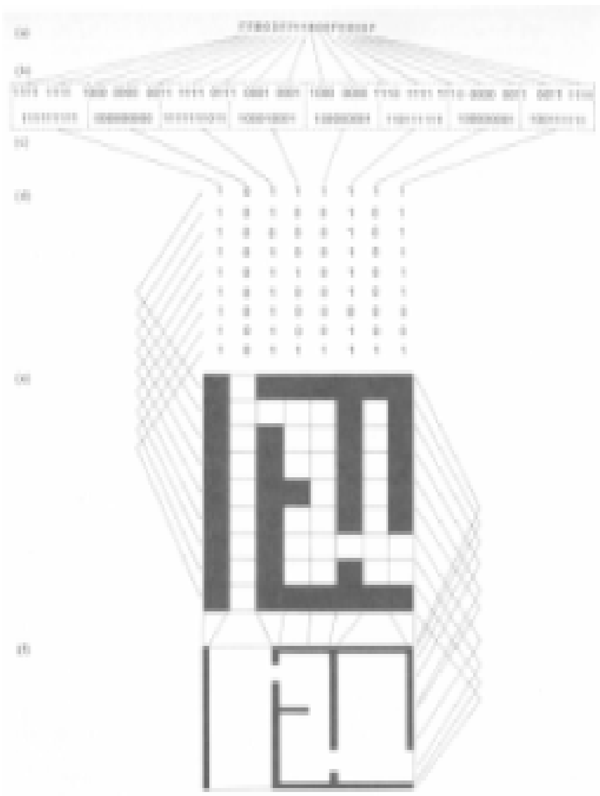


Figure 4: Bevelled version of the Seagram Building, March, 1976.

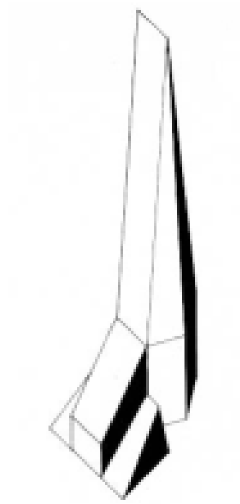
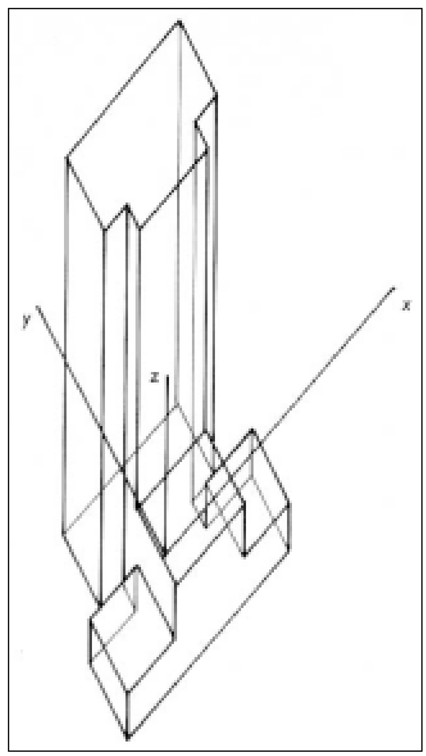


Figure 5: Seagram Building transformed by three-dimensional sheer, Robin Forrest, 1976.



tions became a natural mode of production (once the mathematical structures were in place, representing a cock-eyed cube was as easy as representing an orthogonal one). We see here, slipping out of March's strongly iconoclastic program, the first signs of a new formal vocabulary of transformations, processes, and anti-materialism which would come to define the architectural avant garde of the 1980s and which since has evolved into an entire mode of architectural production.

Twenty years after its completion, it was no longer the Seagram Building itself, but its digital encoding which signaled a new period of architectural production—a period, which we continue to occupy, marked not only by the shift from parallel rule to parallel processing, and the formal consequences which followed, but also by the end of the Modernist social aspirations that motivated March's research. For the growth of computing led not to the rational resolutions of architectural programs envisioned by March's theory, but, ironically, to a new vocabulary of architectural forms suggested by his (and his colleagues') images. Encoded and manipulated, the last monument of high modernism became, unintentionally, the first evidence of a formal strategy which has affected architecture far more deeply than the postmodern facades which dominate our view of the 1970s. The story of the Seagram Building's code teaches a few lessons then: about new technologies, about the end of movements, and about where architectural forms come from.

SYSTEMS LABORATORIES

Planning to study mathematics, March had entered Cambridge as an undergraduate in 1955 with a recommendation from computer pioneer Alan Turing, the central hero, and victim, of the British code cracking effort during World War II. March seems to have thought of architecture only after arriving at Cambridge, where the "new status of the school of architecture under Prof. [Leslie] Martin" convinced him to alter course after his first year (he would receive a first class B.A. in mathematics and architecture).[2] As a result, March studied with Christopher Alexander who also had migrated from mathematics to architecture. March remembers Alexander suggesting in 1957 that "games theory and linear programming might be useful techniques in architectural design,"[3] and though he claims that Alexander's references were beyond him at the time, in fifteen years it would be March who was running a research center at Cambridge devoted to computational design methods and scolding Alexander for sloppy mathematical reasoning—while Alexander had abandoned computers and mathematics for the intuitive knowledge of his "pattern language."[4]

The movement of these two prodigies from mathematics to architecture was not coincidental: the "new status" of architecture at Cambridge, fostered by Leslie Martin, was achieved largely by pushing architecture toward the sciences and mathematics. Best known as the designer of London's Royal Festival Hall (1948–51, fig. 6), Martin was also the first professor of architecture at Cambridge (appointed in 1956).[5] Before the war Martin had edited, with the artists Ben Nicholson and Naum Gabo, Circle: International Survey of Constructive Art, which included contributions from Piet Mondrian, Le Corbusier, Henry Moore, Marcel Breuer, Richard Neutra, Siegfried Giedion, Walter Gropius, Laszlo Moholy-Nagy and Lewis Mumford (figs. 7 and 8).[6] His prewar involvement with modernism—particularly his—"constructivist" faith in an underlying continuity between science and art—gave Martin a receptive predisposition toward the postwar infatuation with science, especially the new technology of electronic computing. The result was an explosion of architectural "science" under his leadership.

Figure 6: Royal Festival Hall, London, Leslie Martin, 1951.

Figure 7: Cover of Circle*, 1937.*

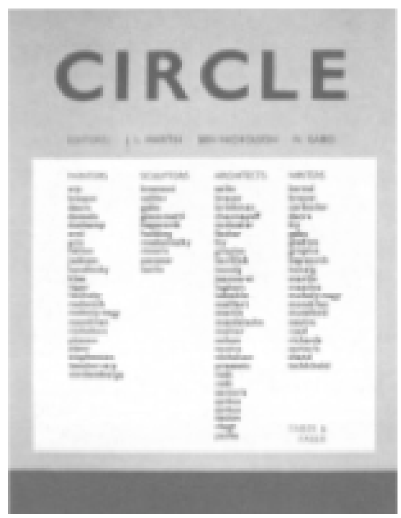
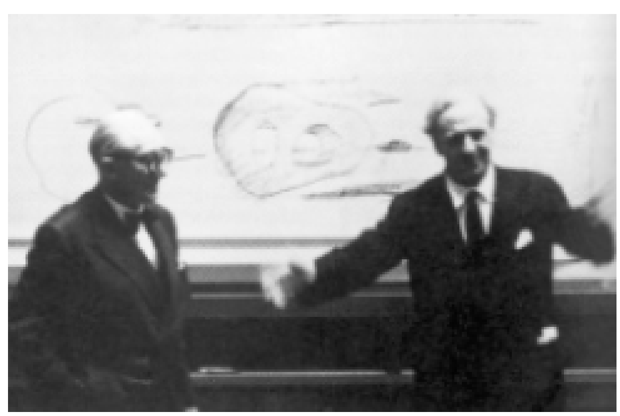


Figure 8: Le Corbusier and Martin, University of Cambridge, 1959.



The turn toward science was also a response to a professional crisis of confidence and lingering sense of inferiority brought on by architects' experiences during the war. The extremities of war had forced to the surface many doubts about architecture as a significant modern profession: did architects possess special expertise? Was their expertise objective or merely based on taste? In times of real need, were architects necessary? In short, was architecture serious business?

The crisis is most clearly illustrated by the wavering of architects' official status in Britain during the war. At the start of World War II, architecture was considered an essential occupation and architects twenty-five and older were reserved from military service and restricted to employment within their profession. Presumably they were meant to aid the construction of military and industrial facilities and to coordinate the planning of evacuations and the use of air-raid shelters. However, most of this work was actually given directly to large contracting firms with few architects involved. Private building was restricted by law in the fall of 1940 and architects were left without work. Awkwardly, the Royal Institute of British Architects was forced to push for reevaluation of their members' status. Architects were first removed completely from the category of reserved occupations, enabling them to enlist in the armed services, and later fractionally reserved. When enlisted, architects struggled to be treated as favorably as engineers.[7]

Meanwhile, the entire British building industry was put under the control of the Department of Works and Buildings. Anthony Jackson makes clear that, in this context, architects had to fight to be viewed as anything other than superfluous aesthetes. [8] After the war, public building exerted a dominant influence on British architecture and urban planning. At a peak in 1955, 45% of architects practicing in Britain worked in public departments, and by 1964 that fraction was still as high as 39% (fig. 9).[9] One result of the centralization and quantification of building information during the war and subsequent reconstruction was the establishment of architectural research as a distinct, and fundable, activity. The scope of architectural research also expanded from concerns technical issues such as heating, lighting, and estimating to a focus in the 1960s on the general relationship of structures to user needs—what became known as environmental design (fig. 10).[10] It is in the context of this last

Figure 9: Plan for the New Town of Crawley, 1947.

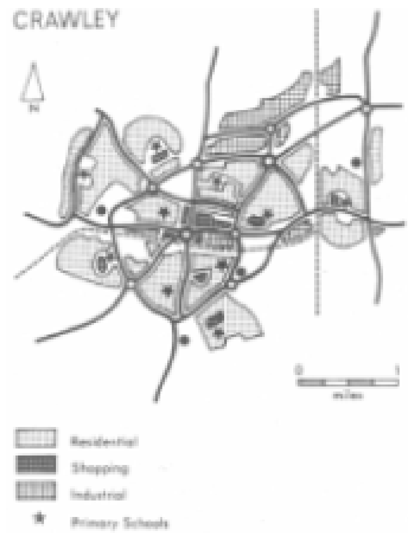
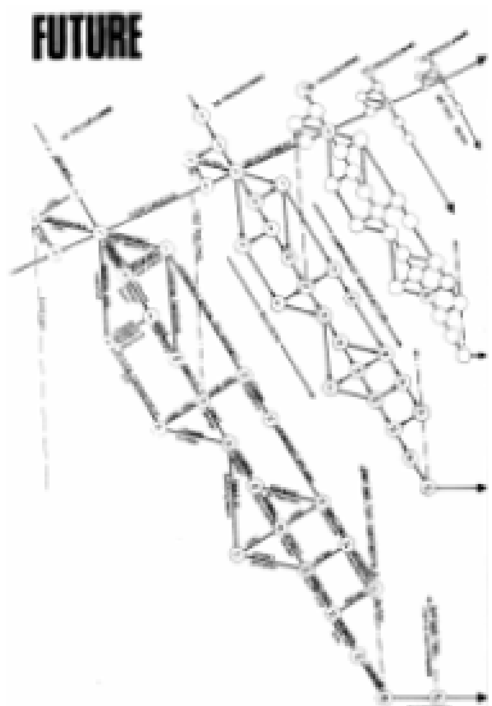


Figure 10: NENK design process, Ministry of Public Buildings and Works, c. 1965.



broadly defined research that architects began to deploy computers in a "scientific" approach to design methodology.

At Cambridge, architects were not alone in adopting a scientific approach: as a visiting scholar noted in 1961,""The university itself . . . should get a different name. Not the University of Cambridge, it really should be called Fenland Tech; and we should all go out and get T-shirts to advertise this message."[11] Or, as a participant in the scene recalled, "Models, quantitative techniques, structuralism seemed to be in the Fenland air."[12] March recalls the influence of work coming out of other Cambridge departments: Mary Hesse's Models and Analogues in Science (1963), Richard Stone's Mathematics in the Social Sciences and Other Essays (1967), Richard Chorley and Peter Haggett's Models in Geography (1967), and David Clarke's Analytical Archeology (1968). When this work was read by researchers in architecture "there opened up the prospect of disciplines merging together through the form of approach, despite the ever-increasing specialization of content."[13] The form of approach in all cases was to be mathematical, and the common tool would be the computer.

A distinct setting for architectural research was established in 1967 with the creation of the Centre for Land Use and Built Form Studies within the Department of Architecture first under Leslie Martin's direction, and then under Lionel March's.[14] Research was no longer conducted by "lone scholars" like Peter Eisenman, who received a Cambridge Ph.D. in 1963 (fig.11), but by "systems laboratories":

> the old Vitruvian view of architecture which related it to the study of classics, divinity, fine arts and music (some of the subject areas in Group I of the Faculties in which Architecture finds itself in Cambridge) has long since been outgrown . . . . Today most of our research workers would connect most easily to engineering, geography and geology, mathematics, and even physics and chemistry: indeed many of them come to us from these disciplines and not from architecture.[15]

Like the scientific labs which were its models, the Centre was financed by research contracts and grants, primarily from British public agencies. By 1971 the center housed sixteen full-time researchers and about an equal number of post-graduate doctoral candidates and visiting associates.[16] The center espoused an explicitly mathematical approach:

> The common method of the Centre's work is to formulate mathematical and logical models which make it possible to characterize and to explore the ranges of spatial patterns which accommodate various activities. . . . The research is mainly in the field of quantitative methods, mathematical and logical models, and computer aides for building and environmental design, planning, development and management.[17]

A STRUCTURAL REVOLUTION

The most zealous version of the Cambridge position was given in a special issue of Architectural Design, published in 1971, edited by March, Marcial Echeñique and Peter Dickens, and filled exclusively with the work of Cambridge researchers and graduates (fig. 12).[18] The one-page introduction to this collection, titled "Polemic for a structural revolution," gives a concise summary of the assumptions underlying their work.

First, that "architecture and physical planning lack adequate theoretical foundations." Second, that only the certainties of mathematics can provide the needed theoretical base. Third, that the interrogation of architecture and planning through mathematical methods is part of a more general""structural revolution" taking place in the social and behavioral sciences which is based on a new awareness of""systems and structures." Fourth, that this mathematical approach is intended to replace the "intuitive skill", "confusion", "sophistical sciences", "individual hunches", "court jesters and acrobats", "private pranks" , "pricey prima-donnas", "hallucinations", "extravagant and empty

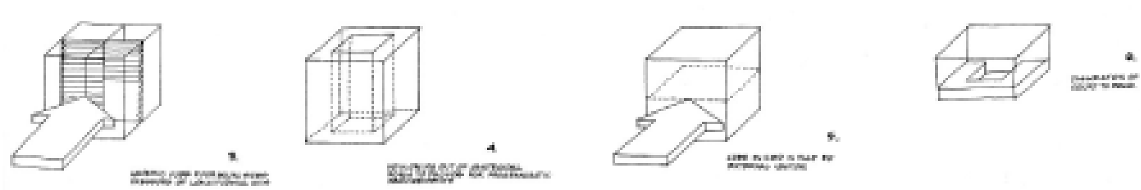


Figure 11: Diagrams from Peter Eisenman's Cambridge Ph.D. thesis, 1963.

Figure 12: Cover of "Models of Environment," special issue of Architectural Design*, May 1971.*

images", "individual expression" and "personal prejudice" which threaten architecture and planning. Fifth, that the structural revolution will require architecture and planning to be closely related to other disciplines with mathematics as a common language. This will mean abandoning irrelevant professional distinctions established in the nineteenth century in favor of a holistic, interdisciplinary approach. Finally, that all of these tenets are intended to encourage objective, communal and socially responsible answers to what is described as the "environmental dilemma" of the 1960s and early-1970s.

As an architectural theory, this polemic is most radical in its rejection of artistic intuition and in its deep iconoclasm. Intuition is condemned on two counts: first, that it is unequal to the complexity of postwar politics, economics, and technology; second, that it is unaccountably private and, so, inappropriate for a discipline as public as architecture. Instead, the methodologists seek an explicit, quantified, design process which is open to criticism and gradual improvement. Regarding architectural images, the damnation is concise: "Draughtsmanship is a drug."[19] In the work of the Cambridge methodologists, texts, formulae, diagrams and computer code replace plans, elevations and photographs as the proper tools of architectural research; and the long-held understanding of the building as an object of sensory engagement is replaced by the idea of the building as a system of functional relationships (although we will see that for March this too might be "aesthetic" in some sense). An architectural theory that rejected images was rejecting the profession's dominant medium of communication—both internally and with the public—as well as the profession's established methodologies, all of which were image based. That the long history of drawing could be replaced by mathematics was not obvious and "revolution" seems a fair term.

Like Reyner Banham, the Cambridge researchers argued that, as yet, modernism's relationship to science had been only metaphorical had led to a host of subjective, thoroughly unscientific, architectural styles (fig. 13). Instead, they claimed, postwar architecture needed to share the methods of the sciences—it did not need to look "scientific" (what architecture should look like was never addressed in the Cambridge work). Strangely though, this doggedly scientific approach would soon find itself demonstrating nothing so much as its own limitations, so that the apparent triumph of functionalism turned out to be its end. Even worse, from the Cambridge perspective, the computer turned out to be a prolific font of novel architectural images and forms rather than a cool calculating machine of architectural logic.

PROGRAMMING PROGRAMMING

In The Architecture of Form from 1973, March emphasizes the distinction between "architectural engineering" and""architectural science."[20] The latter is meant to apply to the analysis and design of the built environment as a whole: a mathematically-based theory of architecture from which, ultimately, new buildings and cities could be generated. "Architectural science" became possible only "with the coming of large, fast and reliable computers during the latter half of the 1960s."[21] March and his colleagues intended to solve building programming with computer programming. Strict functionalism, they believed, could finally succeed through the merger of the two: programming programming (figs. 14 and 15).

Continuing the trajectory begun by Christopher Alexander, this "architectural science" focused on problems of spatial arrangement, particularly problems of architectural plans. These took a number

Figure 13: Walking City on the Ocean, Ron Herron, 1964.

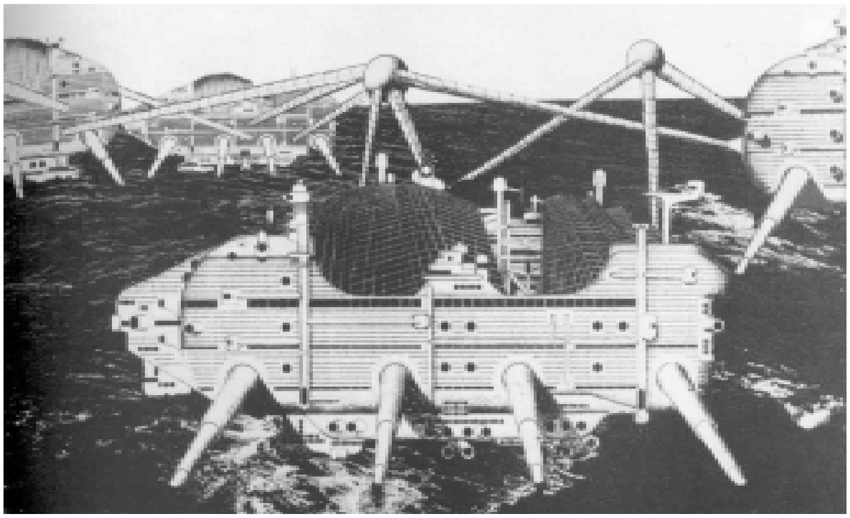


Figure 14: Paper tape used to program an early computer, 1966.

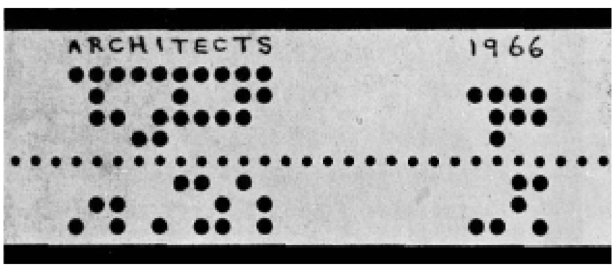


Figure 15: Early CAD system.

of related forms: arrangement of rooms within a given perimeter, of spaces according to a given architectural program, or of activities within a given plan (figs. 16 and 17). Normally the goal was to minimize walking distances for users. Working on these sorts of problems the Cambridge researchers, many of whom had mathematical backgrounds, were able to draw on an existing body of work in topology and graph theory.

However this research faced serious challenges: not only from outside critics such as Alan Colquhoun and Colin Rowe, but soon from within the Centre for Land Use and Built Form Study itself. In a neat turnabout, two Cambridge researchers, Philip Tabor and Tom Willoughby, offered a critique in which careful scientific arguments are used to reject “that most extravagant of fancies, completely automatic design.”[22] Both their reviews of prior work and their own efforts (fig. 18) led Tabor and Willoughby to conclude that quantifiably optimized architectural solutions were largely impossible. They suggested that, at best, quantitative approaches have a limited use for certain very complex problems, and must always rely upon many assumptions which cannot be quantified. Tabor argues against any attempt to automatically produce designs which are too carefully tailored to specific descriptions of use—which is to say that he rejects dogmatic functionalism. Instead, he suggests, “buildings can be designed only for general ease of communication” and that this may be achieved through the use of inherited types.[23]

Figure 16: Dual relationship of a plan graph and its adjacency graph, Philip Steadman, 1976.

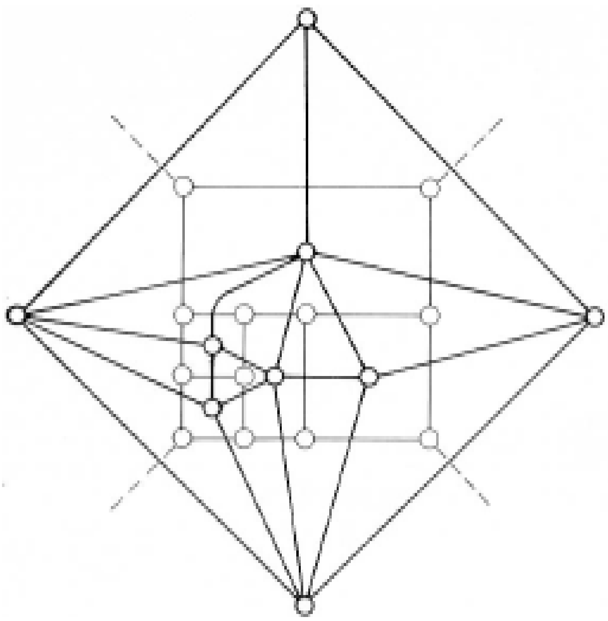
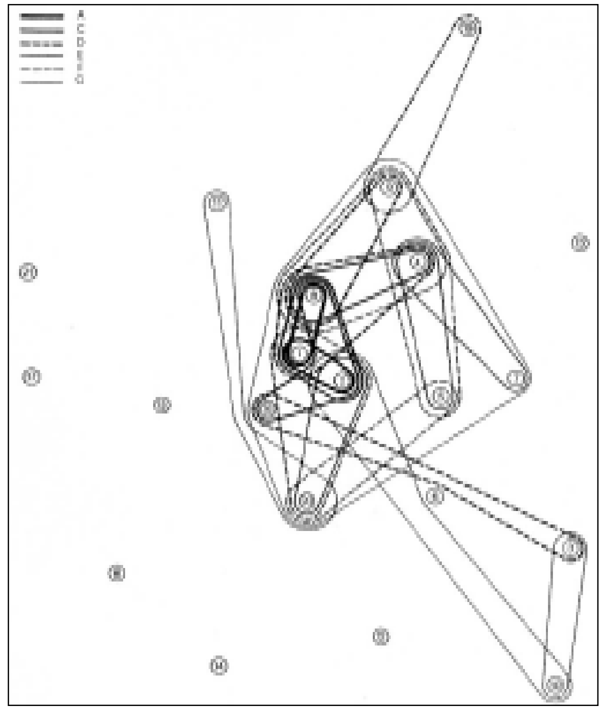


Figure 17: Enumeration of rectangular dissections for 0-6 subdivisions, Steadman, 1976.

Figure 18: Programmatic analysis, treble-linkage Venn diagram, Philip Tabor, 1976.



THE SYSTEMS AESTHETIC

So by the early 1970s, it had become clear that even with the new analytical power of computers there was no convincing path which directly connected functions, formulae and forms. In response, March began to acknowledge these critiques and to describe a more limited, if still central, role for mathematics and the computer in architectural methodology.

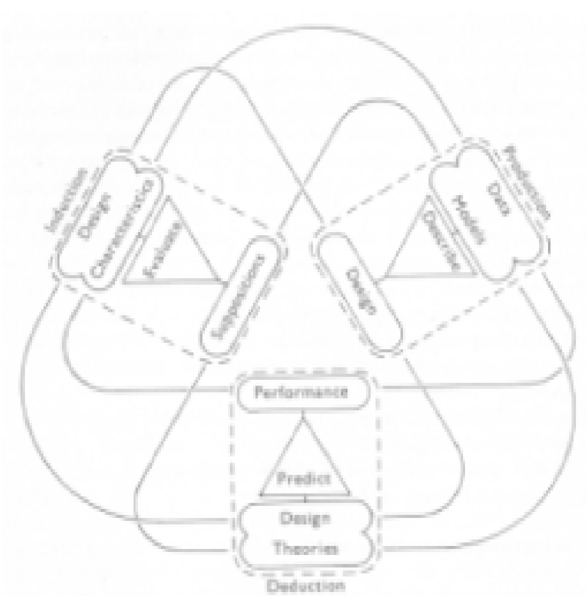
The fullest version of March's theory appears in The Architecture of Form.[24] March begins with a critique of his former classmate Christopher Alexander who is identified as the source of naive scientism in architecture. March then introduces his own theory which, though under the heading "scientific approach," sounds strikingly like that of Rowe or Colquhoun.

Any scientific approach to design must confront the issues raised by the pluralism of individual values and the autonomy of social choice; and must accept the conditionality of degrees of conviction about truth, rightness and goodness.[25] March's model of architectural methodology then springs directly from his reaction to Karl Popper:Popper's philosophy of science cannot be applied directly to architecture.

The philosophy of Karl Popper has had some influence on modern architectural design theory. In the main its impact has been pernicious, but this is as much the result of misunderstandings as it is of Popper's own shortcomings. Just as Popper draws a distinction between logic and empirical science, so too must a distinction be made between these and design. To base design theory on inappropriate paradigms of logic and science is to make a bad mistake. Logic has interests in abstract forms. Science investigates extant forms. Design initiates novel forms. A scientific hypothesis is not the same thing as a design hypothesis. A logical proposal is not to be mistaken for a design proposal.[26]

If architects have missed this distinction, that is largely because they have followed Popper's rejection of synthetic logic which, March believes, design requires since it aims to produce unique compositions rather than universal statements.[27] What March attempts to describe, then, is a rational theory of design which takes synthetic reasoning into account. He does this in two ways, first through the work of the American philosopher Charles Sanders Peirce and then through Bayesian probability theory. The basic structure is the same in both systems: design is presented as a "cyclic, iterative procedure" (like most computer programs) which passes repeatedly through three phases: production, deduction and induction (the "PDI-model", fig. 19).

Figure 19: The PDI (production/deduction/induction) model of design, March, 1976.



We conceive of rational designing as having three tasks—(1) the creation of a novel composition, which is accomplished by productive reasoning; (2) the prediction of performance characteristics, which is accomplished by deduction; (3) the accumulation of habitual notions and established values, an evolving typology, which is accomplished by induction.[28]

March believes that this has always implicitly been the way designs have been developed, whether by individuals, architectural offices or entire building traditions. Not unlike Alexander however, he argues that there is a new need, and a new capability, to make the process explicit:

> If internalized personal judgement, experience and intuition alone are relied upon, the three modes of the PDI-model become inextricably entangled and no powerfully sustained use of collective, scientific knowledge is possible. Design will remain more or less personalistic and a matter of opinion, albeit professional. If the design process is externalized and made public, as it evidently must be for the team work to be fully effective, then the three stages of the PDI-model are worth making explicit so that as much scientific knowledge can be brought to bear on the problem as seems appropriate. In this externalized process it is feasible to experiment with artificial evolution within the design laboratory using simulated designs and environments. New, synthetically derived stereotypes may emerge, and old ones may be given new potential without having to wait for practical exemplification. Design comes to depend less on a single occasion of inspiration, more on an evolutionary history, greatly accelerated as this iterative procedure can now be—a prospect opened up by recent advances in computer representation.[29]

For March the success of this "artificial evolution" depends on the creation of broad, sophisticated computer models which can simulate the demands of the real world and which—following the mandate set out by Leslie Martin in 1959—can unite the disparate concerns of the architect in one design space:

> The mathematical model of the design may be made alive on a computer, complete with its structural integrity, with its environmental climate, with patterns of user activities; it may be disassembled into its component elements and costed; it may be speedily modified, transformed, and manipulated.

Architectural education around the concept of modelling—even penetrating into the teaching and methods of architectural history—becomes, I believe, an intellectually tough discipline around the theme of man and his environment. . . . It removes architecture from the invention of images which reflect the externalities of our technological culture (the machine aesthetic), and penetrates beyond appearances to the elements, relationships, and processes of its very existence: we might coin the phrase, "the systems aesthetic". It turns its back on architecture warped by the competitive individualism of the 19th century and the aggrandisement of personal genius, and faces forward to an architecture balanced in its collective design and its commitment to the promotion of cultural evolution: architecture no longer residing in the souls of individuals, but in the body of a profession.[30]

BOOLEAN DESCRIPTION OF BUILT FORMS

Returning to March's "Boolean description" of the Seagram Building, we can now see all that it meant for him. First, Boolean algebra represented the mathematization of "the very processes of rational argument."[31] Being able to describe buildings through this algebra would make architecture more rational and less intuitive, more scientific and less artistic. This representation would relate architecture to circuit design, topology and information theory rather than painting, sculpture, or music.[32]

Second, all of these associations with mathematics and computer science would give architecture not just a sound epistemological base, but also greater practical standing in a postwar society dominated by science. Architecture would be reconstructed as a serious business with a legitimate, and fundable, role for advanced research like that carried out at Cambridge. March argued that for the first time since the eighteenth century architectural studies had "touched the frontiers of knowledge" and it seemed that architects might regain membership to the Royal Society.

Third, the Boolean description would have been for March only the grammar of a proper architectural model, which would also have included structural, environmental, programmatic and economic information. As nearly as possible this model would have been a simulation of reality, permitting the "artificial evolution" of designs and assuring that the architectural proposal responded to objective criteria, not just the formal whims of the designer. In this way mathematics was put in the service of March's socialist ends.

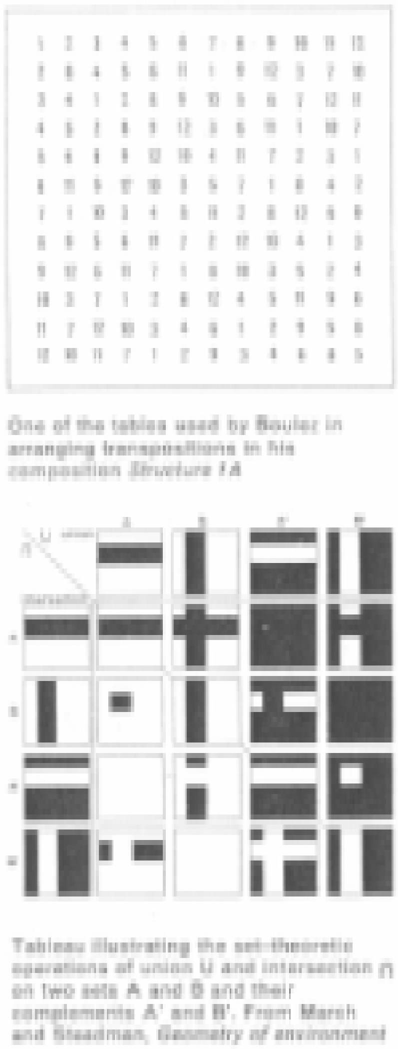
Finally, we must consider an almost contradictory motivation which was only hinted at earlier. For despite the iconoclastic rhetoric, all of this mathematical work was driven by an interest which March himself described as'"aesthetic." Reflecting on his time as a student at Cambridge, March recalled:

> . . . most strongly I recollect Sandy Wilson stopping me in a corridor and saying something about the future possibility of architecture being notated as a mathematical code. This rang bells. It reinforced a thought planted by Bruce Martin that the elements of architecture might be set out like Lavoisier's chemical table, and by a further analogy, that with such a limited means architectural works of the imaginary power of a Beethoven symphony might be constructed (fig. 20) . . . . My impelling motivation at this time was aesthetic. It still is. There are other motivations, but deep down what makes me tick is an aesthetic sense of order, of essential simplicity behind apparent complexity.[33]

Like Leslie Martin, March believed that this sort of order could unite the two cultures of art and science in a non-superficial way.

All of which did not happen. Instead what we see in his paper on Boolean description, and in the Cambridge work which built on it, are the first hints of the formal experimentation which could occur in digital environments freed from the constraints of actual buildings—freed from gravity, from materiality, from structure, from inhabitation, from economics—and freed from the restraints of traditional drafting and modeling techniques. In the beveled and sheared versions of the Seagram build-

Figure 20: Juxtaposition of serial music and architectural research, March, 1972



ing we see the first signs of the—"free space" architecture, "anti-architecture," and""eighty-nine degree" architecture which would sweep the discipline in the next two decades. We see the forms which can evolve in simulations cut loose from their referents. Somewhere in the Cambridge fens functionalism had committed computer-aided suicide, and architecture was left with a new representational system with which to project its images of the future—images created through ever more technical means, but for ever less scientific ends.

NOTES

[1] Lionel March, "A Boolean Description of a Class of Built Forms," The Architecture of Form, Cambridge Urban and Architectural Studies 4, edited by Lionel March (Cambridge: Cambridge University Press, 1976). There is some confusion about the date of the material contained in this volume: March's forward to the volume, which he indicates was written after the articles, is dated June 1973, the book's bibliography contains entries from as late as 1975, and the copyright is 1976.

[2] March, "Modern Movement to Vitruvius: Themes of Education and Research," Royal Institute of British Architects' Journal (Mar. 1972): 101.

[3] Ibid., 101.

[4] See March, "The Logic of Design and the Question of Value," introduction to Architecture of Form; and Alexander introduction to paperback edition of Notes on the Synthesis of Form (Cambridge, Mass.: Harvard University Press, 1971). Strangely, today it is Alexander's pattern language which is well-respected in some computer science circles today.

[5] Peter Carolin and Trevor Dannatt, eds., Architecture, Education and Research: the Work of Leslie Martin: Papers and Selected Articles (London: Academy Editions, 1996).

[6] Leslie Martin, Ben Nicholson and Naum Gabo, eds., Circle: International Survey of Constructive Art (London: Faber and Faber, 1937).

[7] Anthony Jackson, The Politics of Architecture. (Toronto: University of Toronto Press, 1970), 79.

[8] Ibid.

[9] Ibid., 41.

[10] Ibid.

[11] Clinton Rossiter in 1961 as quoted by Colin Rowe in

As I Was Saying: Recollections and Miscellaneous Essays, vol. 1 (Cambridge: MIT Press, 1996), 131.

[12] March, foreword to The Architecture of Form, ix.

[13] Ibid.

[14] In 1974 LUBFS merged with the smaller Technical Research Division of the Department of Architecture to create the Martin Centre for Architectural and Urban Studies—it continues to operate under this new name.

[15] March, foreword to The Architecture of Form, xii.

[16] Nigel Lloyd, description of the Centre for Land Use and Built Form Studies, University of Cambridge (unpublished), 29 Nov. 1971, Library of the Martin Centre, University of Cambridge.

[17] Ibid.

[18] Lionel March, Marcial Echeñique and Peter Dickens, eds., "Models of Environment,"Architectural Design 41 (May 1971).

[19] Ibid., 275.

[20] March, foreword to The Architecture of Form, xiii.

[21] Ibid., xiv.

[22] Tabor, “Analysing Communication Patterns,”The Architecture of Form, 284.

[23] Ibid., 309.

[24] March, “The Logic of Design,” The Architecture of Form.

[25] Ibid., 5.

[26] Ibid., 15.

[27] Ibid., 15.

[28] Ibid., 18.

[29] Ibid., 21-2.

[30] March, “Modern Movement,” 108-9.

[31] March, “Boolean Description,” 41.

[32] Ibid., 71-2.

[33] Ibid., 101.