Nature Normative: The Design Methods Movement, 1944-1967

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ABSTRACT

In the mythic construct of the West, nature, for a considerable era, has served as a seminal broker in basal underpinning discourse. This is despite nature's commutative, convertible and contradictory disclosures. As the antithesis of socio-culture, nature has been the arena of the given, of necessity and compulsion, and a zone of constraint. As "Nature" it has worked as the precipitate of humanity and ministered as the model for human activity. To violate the norms of nature, to be unnatural, has been considered unhealthy, amoral and illegal.

Following the Second World War, constructs of nature, socio-culture and norms were altered in design education and practice. Postwar, an emerging discourse of computer-related technologies contributed to reconfiguring representations of architecture, engineering, product and urban planning in the US and UK. The collective driving these changes became known as the Design Methods movement. Together with trajectories of thought in psychology and psychiatry, discourses materializing from such fields as cybernetics, operations research, information theory and computers altered design processes and education.

This dissertation ranges from examining the politics of funding surrounding an urban planning research center in Cambridge, Massachusetts to elucidating conferences concerning, architecture, engineering, urban planning and product design in the UK. Taking from media theorist Friedrich Kittler that technologically possible manipulations condition what can become a discourse, this dissertation is structured around two threads. One thread concerns how computer-related technologies configured a re-conceptualization of nature and socio-culture in design practice and education. A second thread examines how psychology and psychoanalytic concerns were reworked for design through a lens of computer related technologies. A line between the natural and the normative is questioned concerning concepts of abnormality and deviation.

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Chapter 1 - Introduction: Nature, Norms, and Socio-Culture in Design Methods

My IBM ThinkPad T43 halts in the midst of my typing in Microsoft Word 2002. A blue screen with white lettering appears stating that to prevent my computer from being damaged, Windows XP must be shut down. I suspect there is a conflict between the Sierra Wireless AirCard 595U and the Wireless LAN Mini PCI Adapter. Hoping to download a new adapter, I seek out the website Lenovo.com (which purchased the IBM Personal Computer division in 2005). In a rudimentary sense, I design the path I take through its pages. The principles of technical writing in the early years of the 21st century dictate that my passage through the web page links at Lenovo.com will be represented with the convention of the “>”. The symbolic representation of my navigation is signified as: Support & downloads > Driver matrices > ThinkPad > T43 > Networking: wireless. Arriving at this last page, I learn of “symptoms” that can be “corrected” by an updated Wireless LAN Mini PCI Adapter. Like signs of a diseased organism, like dysphoria indicating depression, I discover my computer has symptoms.

This dissertation explores how representations of design practices and methods after World War II were reconfigured by an intertwining of a discourse of computers and allied technologies with a discourse of psychology and psychiatry. Specifically, I trace strains of psychology, psychiatry and computer related media within a technological and institutional context as these disciplines permeated design discourse in architecture, engineering, product design and urban planning between 1944 and 1967 in the US and UK. By computer related media I refer to the systems sciences which emerged surrounding WWII war research such as cybernetics, operations research, artificial intelligence and the mathematical theory of communications.

This dissertation does not concern designers who envisioned the creation of new products or built forms through technology's potential. Nor does my discussion center on the use of computer hardware and software in the design disciplines of architecture, engineering, product and urban design.[1] This dissertation does not engage exclusively with the built or unbuilt, the made or unmade, but rather primarily with a history of thinking processes of designing. Many of the design practioners and educators I consider formed a loose assembly of international researchers in a campaign known as the Design Methods movement.[2]

Greek myth holds that Hephaestus brought forth Athena fully-formed from the brow of Zeus. But no Hephaestus cracked open the forehead of John Walker, the founder of AutoDesk, to produce the current use of computers in design disciplines. Parallel to the specific technologies that prefigure current computer mediated design tools is a discourse I explore. The historical moment I examine from 1944 to 1967 in the US and UK embraced thinking design methods through new theories and mediums for information selection, storage, transmission and processing. The single designed object was not privileged. Rather, the process of designing was paramount. This history must be rethought

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[1] See Lev Manovich's discussions of Ivan Sutherland's Sketchpad within the context of surveillance technologies. Lev Manovich, "Modern Surveillance Machines: Perspective, Radar, 3-D Computer Graphics, and Computer Vision," Thomas Y. Levin, Ursula Frohne, and Peter Weibel, ed. *Ctrl [space] : rhetorics of surveillance from Bentham to Big Brother* (Cambridge, MA: MIT Press, 2002); Kathryn Henderson's sociological investigations of Computer-Aided Design in engineering practice in Kathryn Henderson, *On line and on paper: visual representations, visual culture, and computer graphics in design engineering* (Cambridge, MA: MIT Press, 1999). Robert Bruegmann's review of the early use of computers in architecture is unparalleled in its detail: see Robert Bruegmann, "The Pencil and the Electronic Sketchpad: Architectural Representation and the Computer" in Eve Blau and Ned Kaufman, editors, *Architecture and its Image*, (Montreal: Centre canadien d'architecture/Canadian Centre for Architecture; Cambridge, MA: Distributed by the MIT Press, 1989).

[2] Ray and Charles Eames provide an important parallel to the Design Methods movement. Like the Eames, the Design Methods movement was interested in the emerging systems sciences in order to rethink processes and practices of the activity of design itself. A fine example of a recent investigation into their computer fascination can be found in Jonathan Harwood's dissertation. Jonathan Harwood, "The Redesign of Design: Multinational Corporations, Computers and Design Logic, 1945-1976," Unpublished Ph.D. Dissertation, Columbia University, 2006.

relative to then emerging networks of technologies and communications.[3] This discourse is crucially important in determining how both computer-mediated design and research developed processes of designing and what they are taken to signify.

I concentrate predominately on a collection of events: for example, the politics of founding a center for urban research in Cambridge, Massachusetts; a selection of conferences in the UK on design methods in architecture, engineering and product design; the mental testing of prospective architecture students in London. Words such as negative feedback, error correction, information and noise overran design discussions. In considering each event I trace conceptual innovations, technological developments and metaphorical linkages between psychology and computer related media as these reconfigured thinking about approaches to designing.

A new nature of humans and psychology emerged, reconfigured by the invention of new technologies for selection, storage, transmission and processing of information. Central to the conception of information for the Design Methods movement was a thermodynamic understanding of information. Drawing on advances in statistics and thermodynamics, under engineer Claude Shannon and statesman of science Warren Weaver's massively influential 1949 *Mathematical Theory of Communication*, information became synonymous with negative entropy, the measure of the order of a system or the amount of information contained in it. The mathematician Norbert Wiener also postulated this equivalence in his 1948 *Cybernetics: or, Control and communication in the*

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[3] Geoffrey Broadbent, *Design in architecture: Architecture and the human sciences* (London: D. Fulton, 1988) is an internal but comprehensive treatment of the techniques of the Design Methods movement. For a chronological overview, see Nigan Bayazit, "Investigating Design: A Review of Forty Years of Design Research," *Design Issues* 20, no. 1 (Winter 2004). In a sense, the classification of this occurrence as the Design Methods movement is anachronistic. It appears to have been first designated as such post hoc by the architect and participant Geoffrey Broadbent. Nevertheless, this term of reference is useful in summarizing the lines of technological postulates and psychological tenets which took place amongst these actors.

animal and the machine and again in his popular 1950 text *The Human Use of Human Beings.* This equivalence altered the research approaches of psychological disciplines throughout the US and UK.

Order and information became synonymous. This is essential, for when order became synonymous with information a pivotal question became: how is this order to be organized? In thermodynamic terms, this order is configured probabilistically: the second law of thermodynamics holds that in any closed system the level of disorder tends to increase at a probabilistic rate. Design methods proponents did not adhere to this strict mathematical definition, but the link between information and order remained pivotal. The question of how the order of information was to be organized was answered by Design Methods advocates in terms of its selection, storage, transmission and processing.

I draw upon Friedrich Kittler's definition of media as a means for the selection, storage, processing and transmission of data.[4] However, I circumscribe his analysis to contend that the functioning of these elements indicates what permits the use of a machine that transforms information. For example, a phonograph's storage is a vinyl record into which sound waveforms are cut; a stylus tracks the grooves of the record causing an electrical current then transmitted by wires to an electronic amplifier. All digital computer hardware works on the principle of memory control,

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[4] Friedrich A. Kittler, *Discourse Networks 1800/1900* (Stanford, CA: Stanford University Press, 1990). The writings of architectural historian Reinhold Martin introduced me to Friedrich Kittler's theories. Martin's text *The Organizational Complex: Architecture, Media and Corporate Space* concerns postwar corporate architecture and design as a naturalization of corporate organizational postulates. Yet Martin's the focus lies on products of design as implicated in the notion of the "control society" put forth by Gilles Deluze and Felix Guattari. However, I sidestep linking Design Methods movement to the control society because such an interpretation requires a radical historicism, replacing everywhere the notion of agent with notion of body. This often but I assert not everywhere fruitful to understanding the post WWII approaches to design thinking. See Reinhold Martin, *The Organizational Complex : Architecture, Media, and Corporate Space* (Cambridge, MA: MIT Press, 2003.)

central processing unit and bidirectional universal switch transmitting data between storage and processing.

This is a particular approach to technology that ultimately resolves itself to a paradigm of instrumental rationality, in terms of means and ends. In this, technology is given in terms of its use value. While it is my position that use confuses heterogeneous technical objects, that, following historian of science Gilbert Simondon, "no fixed structure corresponds to a particular use," the outlook of Design Methods proponents was distinctly use-oriented.[5] It is my argument, that in Design Methods, this language of use was given in terms of selection, transmission, processing and storage. Similarity of use may conceal a variety of structures, but this functionalism - in which highly different material can support the same functional organization - was operative for Design Methods proponents.

The separable functioning of storage, transmission, selection, and processing in machines that process information did not preclude it from applying to the biological. Memory and consciousness were postulated as separate by Sigmund Freud simultaneous to the invention of the phonograph, just as scientists of the organic, technological, and social in the 1950s offered memory, thought and their interrelations in terms of the storage, processing and input-output transmissions of a digital computer.

To elucidate the discussion of designing conceived as the selection, storage, processing and transmitting of information, I invoke two dichotomies surrounding nature as frameworks. These two dualisms are the line between nature and socio-culture and the line between nature and normative. Again, while it is my belief that no categorical separation can exist between socio-culture and nature, between the social-cultural and what exists prior to the socio-cultural, the subject of my historical

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[5] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier-Montaigne,1958), 19.

inquiry investigates how these categorical separations were constructed and altered. Thus I suspend providing a definition of nature or socio-culture. Rather, its numerous and shifting meanings will be revealed as the narrative of my dissertation unfolds.

Thus the first dualism concerns how a division between nature and socio-culture was re-cognized with the advent of computer related media. To give an example of this dichotomy, and the intricacies of the word nature, consider an important figure in this dissertation, Herbert Simon, the polymath political economist and leading developer of artificial intelligence. In a series of lectures in 1967 at the Massachusetts Institute of Technology (MIT), published as *The Sciences of the Artificial*, Simon draws a line between the "natural" and the "artificial." The artificial refers to what is man-made. All else is termed natural. As Simon writes, "you will have to understand me as using "artificial" in as neutral a sense as possible, as meaning man-made as opposed to natural."[6] The artificial applies to organizations that may be purely machinic, such as artificial intelligence, the simulation by computer software of human thought. It can, for Simon, equally apply to a collective of human and non-human actors and technologies such as a corporation. Nevertheless, Simon seeks the "nature" of the artificial for which the artificial can apply to the socio-cultural.[7]

In referring to certain operations of computer programs as artificial intelligence, Simon implicitly defined human thought as natural. To understand an alternative approach to this strict dichotomy between the natural and the artificial, consider briefly the approach of the French psychoanalyst Jacques Lacan. Lacan developed in the mid 20th century a social, cultural and political analysis for understanding psychological symptoms. His semiological, linguistic method shows psychic manifestations to be the consequences of how a human being produces symbolic utterances

[6] Herbert Simon, *The Sciences of the Artificial*, 3rd Edition (Cambridge, MA: MIT Press, 1996), 4.
[7] Ibid, xii.

and interactions. This is offered rather than an ontological presentation, one that seeks the essential nature or innate aspects of the human mind. It is also offered in place of a biological presentation of the psyche that seeks to root psychological symptoms in the neurophysiology of the brain.

Appealing to Lacan is not idle. The second dichotomy upon which I draw to structure the following chapters concerns how a line between the natural and the normative was reconstructed. In particular, I consider how this seam was constituted through a trajectory of thought in which technological commitments met psychology and psychoanalytic traditions.

A norm can serve as a rule of conduct, a principle of conformity. As such, a norm is opposed to irregularity, unevenness, deviation and strangeness. When psychiatry began a thorough study of psychological symptoms in the mid 19^{th} century, psychiatry introduced this sense of norm. Psychological symptoms such as the tremors of hysteria were seen as deviations and subject to corrective principles of conformity. Yet since psychiatry deals with human beings as organic beings and is rooted in medicine, a norm can also serve as a functional regularity, as the principle of an appropriate and well adapted biological functioning. In this sense the normal is opposed to the pathological, disorganized and dysfunctional.

In elaborating concepts of norm and normalcy I draw on the contributions of the historian and philosopher of science Georges Canguilhem. Active in the 1950s and 1960s, he was not unknown to the design methods proponents. His work concerns norms and normality in terms with which design methods proponents and dissenters were engaged.

In Latin, *normalis* means perpendicular, and *norma* is the word for T-square. In Canguilhem's terms,

> The concept of right...qualifies what offers resistance to its application of twisted, crooked or awkward...The property of an object or fact, called normal, is the ability

> to be considered as the reference for objects or facts which have yet to be in a position to be called such. The normal is then an extension and the exhibition of a norm. It increases the rule at the same time it points it out. It asks for everything outside, beside and against it that still escapes it. A norm draws its meaning, function and value from the fact of the existence, outside itself, of what does not meet the requirement it serves.[8]

Canguilhem argues that the norm does not function as a natural law but rather as an exacting project performed in the domain to which it is applied. The normative joins a principle of qualification and correction, an attitude of intervention and alteration.[9]

However, these two dichotomies of nature/normative and nature/socio-culture are merely frames for discussion. They overlap. For example, conceptions of normalcy are often closely linked with viewing socio-cultural adaptability as natural, in which deviations from a rule of social conduct is explicitly contrasted to the rule as abnormal. The intricacies of these two frames can perhaps be elucidated through a quote on rationality by the philosopher Felix Guattari:

> Individual and collective behaviors are governed by multiple factors. Some are of a rational order, or appear to be, like those that can be treated in terms of power relations or economics. Others, however, appear to depend principally on non-rational motivations whose ends are difficult to decipher and which can sometimes even lead individuals or groups to act in ways that are contrary to their obvious interests.
>
> There are numerous ways to approach this "other side" of human rationality. One can deny the problem, or fall back on the usual logic regarding normalcy and proper social adaptation. Considered this way, the world of desires and passions leads to nothing in the end, except to the "jamming" of objective cognition, to "noise" in the sense that communication theory uses the term. For this point of view, the only course of action is to correct these defects and facilitate a return to prevailing norms. ...[In this perspective] the unconscious is supposed to be something at the

[8] Georges Canguillem, *The Normal and the Pathological* (Cambridge, MA: Zone Books, 1992), 239.
[9] For Michel Foucault's interpretation of Canguilhem's conceptualization of norm, see Michel Foucault, *Abnormal: Lectures at the Collège de France 1974-1975* (London: Verso, 2003). My interpretation draws on certain similar points of Canguilhem's, but not from the perspective of Foucault's concerns regarding power.

> back of the head, a kind of black box where mixed feelings and weird afterthoughts accumulate; something that should be handled with care.[10]

Guattari is commenting on irrationality which has historically been viewed, particularly starting in the 1950s, as an engineering problem. Implicit is a vision of behavior as a sequence of signals and information flows. Irrationality causes "noise" in the sense of distortions or additions which interfere with information transfer. Irrationality interferes with signals so as to render them unintelligible by "jamming." The unconscious, as a natural aspect of the human psyche, is naturalized as a black box, a term much used in the systems sciences of cybernetics and operations research to denote any automatic apparatus performing intricate functions whose workings are unknown. A response to these engineering problems of irrationality, Guattari notes, has been to treat irrationality as a fault and to encourage prevailing norms of normalcy and appropriate adaptation. Irrationality as a psychological symptom is viewed from this naturalized black box perspective as a violation of the norms of socio-culturally adaptability.

When design practices are likened to a machine that transforms information, this permits them to be dissected and analyzed as a machine that transforms information. Humans have been compared to machines forever, but which machine is historically circumscribed. Which machine is relevant, for in comparing human processes of designing with machine operations, aspects of machines are likened to aspects of the nature of designing. What was taken as the nature of designing became, I contend, amongst the Design Methods movement an unquestioned basis from which all other design investigations proceeded.

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[10] Félix Guattari and Sylvère Lotringer, *Chaosophy: soft subversions* (New York, N.Y.: Semiotext(e), 1996), 192-3.

Which machines human designers are compared to have implications for what is taken as the contingent, socio-culturally inscribed procedures for designing and what is viewed as its nature. What nature is taken to be is relevant for the socio-cultural because the socio-cultural is the human interactions and institutions that are subject to normative regulation. What the nature of design is taken to be is relevant, for deviations from this nature can be taken as abnormalities that need to be corrected. Which machines humans are compared to have implications for the norms of designing, for which machine can shift what is taken as the nature of designing. In turn, this can rework which norms are needed to correct and intervene, qualify and alter.

Central to my arguments is also Kittler's notion of a discourse network. Kittler defines a "discourse network" as a "network of technologies and institutions that allow a given culture to select, store, and process relevant data."[11] However, there is a distinction Kittler holds between bodies and actors. A body is given meaning in and by culture, coded and placed in a social network. A body is structured, inscribed, constituted and given meaning socio-culturally and historically. For Kittler, a discourse network is constituted by bodies in this sense. An actor, alternatively and for my purposes, is an individual with specific interests, agendas and politics for creating change. An actor is both inscribed by the socio-cultural and has the agency for altering specific historical concerns.

Integral to the notion of body is a radical historicism. This is the sense of viewing all social and cultural phenomena as relative and historically determined. The focus of analysis shifts to the processes that make a particular socio-culture possible. I do concern myself with what historical factors made the Design Methods movement possible. However, the notion of an actor's interests and

[11] Friedrich A. Kittler, *Discourse Networks 1800/1900,* 369.

individual political agendas must be thought, I believe, together with the limits and structures placed on that actor by the socio-culture in which she resides.

For example, I begin, in Chapter Two, with a discussion of the politics of funding a center for urban research at MIT and Harvard University. I argue that the model for both funding the center and the content of its practice were drawn from the WWII inventions of the systems sciences. This urban research center, the Joint Center for Urban Studies of MIT and Harvard, not only attempted to apply the methods of the systems sciences to urban planning. The Joint Center also sought to model itself as an interdisciplinary research center in line with the radical reorganization of research that occurred in developing systems war technologies. In this chapter I employ the notion of actors and their interests alternately conflicting and agreeing with the agendas of the institutions and government factions involved. I also investigate what makes possible these institutions and the socio-culture they entailed.

I follow lines of dichotomies to illustrate their shifts and collapses when new technologies and psychologies confronted theories and practices of designing. In Chapter Three I discuss the arrival of the architect-to-be Christopher Alexander as a graduate student at Harvard University. This narrative takes Alexander's dissertation, published little altered in 1964 as *Notes on the Synthesis of Form*, as a jumping off point to trace how abnormality has been portrayed relative to design theory when a discourse of computer related media intertwined with a discourse of psychology.

I argue that in *Notes* a machine that transforms information is proposed to explain the process of designing in non-modern design cultures. Alexander refers to these as "unselfconscious" design cultures. However, in Alexander's portrayal of contemporary1960s design cultures, which Alexander refers to as "selfconscious" design cultures, I contend that the process of designing fails to exhibit the utility of a machine that transforms information. Human designers for Alexander continue to behave as machines, yet as disordered machines deviating abnormally from purposeful design behavior and in which intuition becomes a machinic disorder. Alexander allies these failures in designing to psychological pathologies. This blurred distinctions between disorders of nature and socio-culture because humans were seen as dysfunctional machines and malfunctioning machines were seen as pathological organisms.

The aligning of psychological pathologies with machinic failures also occurred in the institutional context in which Alexander was embedded, the Harvard Center for Cognitive Studies (CCS). This is where Alexander, in addition to his PhD work at the Harvard Graduate School of Design, was engaged in conducting psychological experiments. For both Alexander and influential CCS figures, the non-rational was allied to psychological pathologies and psychological pathologies were envisioned applicable to human or machine.

Mental disorganization was constructed as dysfunction of information storage, selection, transmission, and processing. The treatment for this malfunction, by Alexander and affiliates of the CCS, supports a normative view of mental disorganization as pathological. Cultural adaptability and social norms were then, in Alexander, enlisted to cure the diseased information machine that was the designer. A line between nature and norms enter when norms were called upon, I argue, to return the designer to his or her proper instrumental functioning as always having been a machine, free of disorganization and mental disorder, which transforms information. The parallel of function in terms of use value and dysfunction in terms of failed use value enforced a space of correction which saw abnormality and mental disorganization as undesirable.

The duality between nature and socio-culture underscores how humans and machines were reconceptualized in design practice and theory with the advent of information theories, technologies and psychologies. This issue is again brought to the forefront when I cross the Atlantic to the UK in Chapter Four to further investigate how computer related media altered methods and practices of design processes. Chapter Four is centered on a 1962 "Conference of Systematic and Intuitive Design Methods." I argue that during the 1950s and early 1960s in the UK systems design became communications design. Humans were either guised as an equivalent of machines or else humans and machines were seen as complementary entities of a system of mechanical forces coupled with flows of information. In the latter, machines and humans were thought to communicate through information channels and feedback loops, but each performed an allotted division of labor. The nature/normative split is significant when I consider how norms in designing were rethought in terms of natural limits of human capacities as information processors.

Chapter Five expands the previous discussion to incorporate information processing in engineering design models. This is achieved by examining a series of conferences on engineering education and culminating the 1965 "Symposium on Design Methods." Again, the nature/normative is further paramount when I introduce the role of models in Design Methods. A norm can be a model of conduct or a model of functional regulation. A model can serve an imitation or an ideal, that which deserves to be imitated. As a model of functional regulation, a model is a model of nature. A model of the process of designing can serve to abstract a fact of "what is" designing, to imitate the nature of design. Design models in Design Methods appealed to the biological basis of cybernetic and information processing models. Not only were models of design imitations of the nature of design, but the nature of design came to imitate the ideal of biologically-based information processing models.

Such design models became both an imitation of nature and an ideal of the nature of design. Additionally, a norm can be a model of conduct. Yet Chapter Five argues that the regulation of design according to educational norms was replaced by the technological regulation of the information processing models.

By considering in particular hospital design and the psychological testing of prospective architecture students, in Chapter Six I argue that designs and designers were viewed as equilibrating around an assumed measurable norm. This norm took a statistical average as normal and abnormal deviation from this standard was indicative of poor designers or design work. I illustrate how this parallels then-popular psychoanalytic models of normality in which mental illness is viewed as a "real" abnormality measurably different from a normal state. This optic furthered the ideal of designers as information processors discussed in previous chapters in which a new facet was added: the designer as intuitive statistician. Internal mental processes and externalized design operations were seen as rooted in the calculation of probabilities.

In Chapter Seven I examine a backlash to the ideal of design as information processing among architectural practioners and educators at the 1967 "Conference on Design Methods in Architecture." Those who objected to this perspective proposed that the norms of design method, particularly as codified in Christopher Alexander's dissertation and his later 1960s design theory, must be questioned. It was contended that what constitutes norms of designing are themselves socio-cultural concepts of normativity. Following tenets of a parallel movement in anti-psychiatry, design methods objectors questioned constitutions of normativity which saw the statistical average as the normal and the construction of the normal as conflict-free adaptation.

Lastly, in Chapter Eight, I consider how Alexander's 1970s work on architectural patterns holds commonality with the precepts of new media proposed by recent media theorist Lev Manovich and that in turn both can be assimilated to functions of selection, transmission, storage, and processing. I conclude that this is problematic because it means the world is cut up as data to be operated upon in one of four ways. As such, a new basal underpinning discourse emerges given in these terms. A new nature of human action in the world, a stance from which all other activities proceed, is circumscribed by these categories.

Throughout this dissertation I consider how technologies for the selection, storage, transmission, and processing of information reconfigured designing. I set this within the frameworks for how this reconfiguration, in turn, altered boundaries between the nature, socio-culture and norms. I now turn to both what conditioned the possibility of the use of the systems sciences in urban planning and the effects this use had on what urban planning was taken to signify.

Chapter 2 - The Joint Center: Technological Solutions for Urban Environments, 1952-1959

The language of a press release issued by the Massachusetts Institute of Technology (MIT) Office of Public Relations on November 17, 1957 presents a battle being waged against a diseased urban organism. The release quotes acting MIT President Julius Stratton stating "the present problems of our great urban areas are already grave."[1] He goes on to assert that to "determine what the physical form of the metropolitan region of the future should be" is a "war against blight, congestion, and malfunction [which] cannot be successfully fought with weapons of a bygone era."[2] To fight this urban sickness, the release goes on to announce the formation of a Center for Urban and Regional Studies, as part of the MIT School of Architecture and Planning (see Figure 2.1). This "bold new approach" towards urban "problems" was to include the use of the IBM 704 computer (see Figure 2.2) and "the sophisticated mathematical methods - such as network theory and information theory" that "provide the operating logic for such complex machines as giant digital computers and the M.I.T. men think they may prove equally useful in providing an understanding of the way various factors affect the growth of cities."[3]

Indeed, cities had been compared to organisms, or socio-culture compared to nature, throughout 19th century social theory. For example, Herbert Spencer compared cities to cellular organisms which must function by assimilation of part to whole.[4] The 20th century modernism of

[1] Office of Public Relations, "For Release in Papers of November 17, 1957," Box 6, Folder "Joint Center for Urban and Regional Studies 2/2," MIT Office of the President, Records, 1930-1959 (AC 4), Institute Archives and Special Collections, MIT Libraries, Cambridge, MA. Hereafter IASC.
[2] Ibid
[3] "How M.I.T. Will Blueprint the Perfect City: Giant IBM Computer May Be Used To Aid Researchers With Problem," Nov 17, 1957, *Boston Globe*, a-31.
[4] Herbert Spencer and Robert L. Carneiro. *The Evolution of Society: Selections from Herbert Spencer's Principles of Sociology* (Chicago: University of Chicago Press, 1967)

Siegfried Gideon, Walter Gropius, and CIAM all proffered cities akin to organic bodies.[5] In comparing cities and diseased organisms, as Donald Schön has observed of metaphorical constructions such as "slums are blighted," the perspective of blight carries into slums.[6] For slums to be blighted they must be living although sick life forms. By the mid-20th century, framing urban communities as facing problems of congestion, disease and malfunction - conditions which beset ailing organisms - was a common claim. Under the theme of urban blight, the 1950s saw federal urban renewal clear urban cores and the national highway program claim large tracks of land through numerous cities.[7] The socio-cultural order of the urban agglomeration was seen in terms of the natural order of an organism, what is scientifically natural and necessary for a society-organism to function. However, according to the above press release, it was contended that urban areas' sickness could be healed through the logic by which a computer operates. As such, the disciplines responsible for computers and allied technologies, and, as shall be shown, particularly the systems science of cybernetics, provided a new medium for describing the organization and functioning of the socio-culture of cities. Comparisons to nature continued, but these analogies were reconditioned through a narrative for which "information" became an operative term.

The founding of the Center for Urban and Regional Studies was an intermediary step in an attempt by the MIT Department of City and Regional Planning to establish an independently funded

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[5] Siegfried Giedion, *Mechanization Takes Command* (New York: Oxford University Press, 1948); Eric Mumford, *The CIAM Discourse on Urbanism, 1928-1960* (Cambridge, MA: MIT Press, 2000); Walter Gropius, *Scope of Total Architecture.* New York: Harper, 1955).

[6] fn

[7] Constance Perin, *Everything in its Place: Social Order and Land Use in America* (Princeton, N.J.: Princeton University Press, 1977); Kenneth T. Jackson, *Crabgrass Frontier: the Suburbanization of the United States* (New York: Oxford University Press, 1985); Joel Garreau, *Edge city:Llife on the New Frontier* (New York: Doubleday, 1991); Michael Sorkin, *Variations on a Theme Park: Scenes from the New American City and the End of Public Space* (New York: Hill and Wang, 1992).; Edward Relph, *The Modern Urban Landscape* (Baltimore: Johns Hopkins University Press,1987).

center for urban research. Stretching back to the early 1950s, the efforts at establishing a research center would culminate in the founding of the Joint Center for Urban Studies of MIT and Harvard University (JCUS) in 1959. Hoping to follow in the esteemed footsteps of MIT's WWII-forged, independent research centers, the founders preliminarily aimed for a venue in which they could immerse themselves in research, free from teaching and the quotidian tasks of academic departmental operations. However, the JCUS's founders were more significantly among the first and most well funded advocates of an approach to urban planning that invoked the burgeoning systems sciences. In its early years it received millions of dollars from the Ford Foundation, the Venezuelan government, the Metropolitan Planning Commission, the Gillette Company and the Municipal Manpower Commission, to name but a few of its financial contributors.[8] Endorsed by fiscal support from governments, foundations and business, the JCUS stood at the cusp of an emerging vision in urban planning, yet the politics of its founding have not been examined. Why a system's approach? How was it to solve urban "problems"? Whose interests did it serve? Furthermore, one of its earliest collaborators was the architect Christopher Alexander, who would be massively influential to the architectural faction of the Design Methods movement.

When the JCUS doors opened in April 1959, indeed not all of its researchers were urban planners promoting a systems approach. Its group of affiliates and their interests was varied. For example, architect Edward Sekler considered the potential of applying art historical methods to the analysis of city form and historian Morton White wrote a history of prominent intellectual's attitudes towards the city in the 19th and 20th centuries. However, these studies were outliers. Whether looking to planner Lloyd Rodwin's systems-optic towards the Guayana region of Venezuela, political

[8] "Summary of Grants," Box 6, Folder "M.I.T. Harvard Joint CTR 2/4," AC 4, IASC.

scientist Robert Wood's emphasis on technological innovation in transportation planning, or chemist-turned-planner Richard L. Meier's interest in applying findings of information theory to city form, the predominant vision of the JCUS in its early years was one of systems sciences.[9]

In 1988 the JCUS would drop its MIT affiliation, join with the Harvard Business School and be renamed the Joint Center for Housing Studies (JCHS). The JCHS currently publicizes its mission as "generat[ing] new information on housing and mortgage markets by analyzing large-scale databases, designing housing market indicators, and applying innovative analytical approaches to housing problems."[10] Thus, although techniques employed today are greatly different from those of the late 1950s and early 1960s, the JCHS's still focuses on "information", asserting that it "serve[s] as a clearinghouse for information about trends in housing."[11] The JCUS's originators, who included influential urban planners such as Martin Meyerson (see Figure 2.3) and Rodwin, likewise offered an emerging vision of urban areas as systems and flows of information. Yet, more than providing simply a new terminology, disciplines such as cybernetics and operations research contributed to a new nature of cities conceived in informational terms and a new stance from which planning discussions would proceed. These fields offered a new nature to urban concerns in both senses of the term. They helped turn cities as organic entities into systems of information and provided a new substratal given from which all planning was to proceed.

Specifically, cybernetics and Operations Research provided a mode of decision making reflected in the use value of machines which process information. For information technologies, in their use value, must select information in action separate and prior to the primary processing of that

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[9] Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University, *The First Two Years* (Cambridge, MA: Joint Center, 1961).

[10] http://www.jchs.harvard.edu/research/index.html. Accessed July 23, 2007.

[11] "Background information about The Joint Center for Housing Studies." http://jchs.harvard.edu/media/index.html. Accessed March 5, 2008.

information. For example, in a phonograph, a vinyl record into which sound waveforms are cut is tracked by a stylus. This causes an electrical current to be transmitted by wires to an electronic amplifier. All digital computer hardware works on the principle of memory control, central processing unit and bidirectional universal switch transmitting data between storage and processing. Similarly, the organization of planning information among the founders of the Joint Center was conceived in terms of the selection and processing of data: decision making became information selection and subsequent information processing. The choice of a planning goal became aligned with data selection, and the execution of a plan aligned with data processing. The JCUS's planners use of cybernetics and operations research indeed blurred existing boundaries between nature and socio-cultural productions, but only to provide information and feedback as the new nature of planning. Systems and information were viewed as given, serving as bases from which all other planning research was to proceed.

Furthermore, the specific concerns of earlier city planners were evacuated in favor of a systematic mechanism to order and control the organization of information. For example, cybernetics seeks to isolate a formal device of information feedback common to both animal and machine - regardless that the first contains proteins and the second transistors. In Operations Research, an organization comprised of humans and technology alike - such as military personnel and radar sets to track enemy submarine actions - is optimized by isolating formal properties. The social or cultural specificities of location of machine or operator are dispensed with in favor of assigning geographic coordinates. Concerns which had hitherto dominated 20th century planning discourse, such as sprawl, green space, or density, were disregarded in favor of a systematic planning method for the organization of information. Cities continued to be compared to organisms, but now both urban areas and natural life forms were explicable by processes of information modulation and transformation.

Joint Center advocates thus turned to Operations Research and cybernetics for the techniques pioneered by these fields. These, which are referred to here as foreground contexts, are disciplinary specific practices, concerning the content of research.[12] Yet what larger, institutional issues, those broader than the specific discipline of urban planning, conditioned the possibility of the JCUS's successful funding and establishment?[13] What were the politics with which its founders had to grapple to create a successful campaign? Institutional aspects, referred to here as background contexts, that provided for the negotiation of this independently funded urban research center must be addressed to understand how planning's reconfiguration through systems and information sciences of nature and socio-culture was successfully instantiated.

One background context which conditioned the political possibility of the Joint Center was a 1950s movement sponsored by government, foundations and academia to employ social scientists in

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[12] I draw these terms from John Campbell, although his usage varies from mine. See John L. Campbell, *Institutional Change and Globalization* (Princeton, N.J.: Princeton University Press, 2004), 247, esp. Ch. 4. Other institutional theorists who have been particularly helpful to my account are Paul J. DiMaggio, "Interest and Agency in Institutional Theory," 3-21 in Lynne G. Zucker, ed., *Institutional Patterns and Organizations: Culture and Environment,* (Cambridge: Ballinger, 1988); John W. Meyer, John Boli, and George M. Thomas, "Ontology and Rationalization in the Western Cultural Account," 12-37 in *Institutional Structure: Constituting State, Society and the Individual,* George M. Thomas, John W. Meyer, Francisco O. Ramirez, and John Boli, eds. (Beverly Hills, CA: Sage 1987); Pierre Bourdieu, *Acts of Resistance: Against the Tyranny of the Mark*et, (New York: The New Press, 1998); Fred Block, *The Vampire State: And Other Myths and Fallacies about the U.S. Economy,* (New York: New Press, 1996).

[13] See John L. Campbell, *Institutional Change and Globalization* (Princeton, N.J.: Princeton University Press, 2004), 247, esp. Ch. 4. Other institutional theorists who have been particularly helpful to my account are Paul J. DiMaggio, "Interest and Agency in Institutional Theory," 3-21 in Lynne G. Zucker, ed., *Institutional Patterns and Organizations: Culture and Environment,* (Cambridge: Ballinger, 1988); John W. Meyer, John Boli, and George M. Thomas, "Ontology and Rationalization in the Western Cultural Account," 12-37 in *Institutional Structure: Constituting State, Society and the Individual,* George M. Thomas, John W. Meyer, Francisco O. Ramirez, and John Boli, eds. (Beverly Hills, CA: Sage 1987); Pierre Bourdieu, *Acts of Resistance: Against the Tyranny of the Mark*et, (New York: The New Press, 1998); Fred Block, *The Vampire State: And Other Myths and Fallacies about the U.S. Economy,* (New York: New Press, 1996).

solving social problems, of which urban problems were viewed as a subset. As such, through an institutional emphasis on interdisciplinarity, social planning, including, say, economic and educational planning, became privileged over the specific interests of city form that were of concern to the Joint Center's founding planners. Interdisciplinarity had to be carefully negotiated by Joint Center proponents to maintain the form-based relevance of urban planning. For, while the founders sought a formal solution that evacuated concern with city materiality such as green space, they no less retained a concern with the form of the city. Rather, this city form was evacuated of particularities. A generic concern with city form was favored over specific agendas for city layout.

However, the same institutional and political setting which emphasized a focus on interdisciplinarity also provided the Joint Center founders with a central bargaining tool. This was the background context of an institutional and political bias towards basic over applied research, fundamental inquiry without immediate usefulness privileged over the search for practical solutions. In the founding of the Joint Center this bias meant reference to "basic research" was used as leverage for greater freedom in pursuing academic interests in light of institutional agendas away from a concern with the form of the urban landscape.

In both the Joint Center's proposed organization of interdisciplinarity and in emphasizing the importance of basic research, Joint Center advocates turned again to systems sciences research. This turn was not to these fields' material content but rather their model of interdisciplinarity and their attitude towards basic research. Significantly, turning to the organization of research of systems sciences provided a model for urban planning's autonomy. Thus it is argued that the shift to an approach to urban planning that mirrored the use-value of information technologies and evacuated an orientation towards specific city form was more than a change in jargon. It re-categorized nature and socio-culture through a discourse of systems and information, but for the specific purpose of creating a field of possibility for planners to make a disciplinary place for themselves.

Cybernetics in City Planning

To first address the assertion that decision making became convertible in human or information processing machine, it is important to consider a piece of armory. During WWII, the mathematician Norbert Wiener's work in calculation and antiaircraft tracking contributed to the development of his anti-aircraft (AA) predictor (see Figures 2.4, 2.5). The AA predictor was designed to map the erratic flight of an enemy pilot. From tracking this data it was to anticipate the enemy's future position through the mechanism of controlled feedback: the difference between the current state and desired state was used as input to bring the mechanism closer to the desired state. The predictor then subsequently fired an antiaircraft shell.

This behavior, exhibited in the workings of the AA predictor, would feature prominently in a 1943 article by medical doctor Arturo Rosenblueth, Wiener, and engineer Julian H. Bigelow entitled "Behavior, Purpose, and Teleology."[14] This paper was to provide a definition of teleology released from the "vague concept of a 'final cause.'"[15] For the Aristotelian understanding of "final cause" of teleology offers a form of backward causation: the end to which an action is directed precedes the action, future conditions are considered the cause of the end in question. Yet in Rosenblueth et al, teleological behavior was now considered "purposeful" if controlled by the error of the action, by negative feedback, that is, "by the difference between the state of the behaving object at any time and

[14] Arturo Rosenblueth, Norbert Wiener and Julian Bigelow, "Behavior, Purpose and Teleology," *Philosophy of Science* 10, no. 1 (Jan., 1943):18-24.
[15] Ibid, 23.

the final state interpreted as the purpose."[16] The claim was that teleological behavior was observable in certain machines such as the AA predictor, and namely machines manifesting negative feedback (see Figure 2.6). Such servomechanisms, or powered mechanisms in which, in response to an input at a low energy level, a controlled motion of higher power is produced, were termed "intrinsically purposeful."[17] Most strikingly, humans and machines were essentially alike in their pursuit of purposeful actions.

Wiener's effort would be integral to his developing a new science, cybernetics, its name accentuating its debt to the history of servomechanisms.[18] Central to the argument in Wiener's1948 book *Cybernetics: or Control and Communication in the Animal and the Machine*, was the equivalence of energy and information (see Figure 2.7). The second law of thermodynamics states that energy in any closed system will probabilistically increase in entropy, or disorder. Wiener saw equivalence between energy and information, that information undergoes a similar process. Reference to information rather than energy would become a dominant feature of Wiener's writings.

It is central to consider that MIT's urban planners were aware of cybernetics potential for city planning as early as 1950. For in 1950, three MIT professors would contribute an article "How U.S. Cities Can Prepare for Atomic War" to *Life* magazine. The article's authors, Wiener, political scientist Karl Deutsch and historian of science Giorgio de Santillana, contacted MIT planning Professor Lloyd Rodwin and head of City Planning John Howard. Deutsch and Wiener described

[16] Ibid, 24.
[17] Ibid, 19.
[18] Peter Gallison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21, no. 1 (1994), 228-266.; Otto Mayr, *The Origins of Feedback Control* (Cambridge: M.I.T. Press, 1970), 151.; David Mindell, Between Human and Machine: Feedback, Control and Computing before Cybernetics (Baltimore: John Hopkins University Press, 2002).

Rodwin and Howard's contributions as "substantial."[19] The article proposed that "a city is primarily a communications center, serving the same purpose as a nerve center in the body."[20] In this "defense-by-communications," they proposed that radial networks of highways - "life belts" - should be built to serve as conduits from urban centers in the event of nuclear attack (see Figure 2.8).[21] Cities are compared to organisms, but both are reconfigured through a filter of communication, of information.

A volume Rodwin edited, titled *The Future Metropolis*, included a contribution by Deutsch, who offered that "any metropolis can be thought of as a huge engine of communication."[22] In the same volume, Rodwin proposed a definitely cybernetic form of city planning:

> A combination of two devices now absent from almost all development programs may prove desirable, if not indispensable. One is the need for a national urban development plan; the other for a regional capital budgeting procedure. The former would provide the sense of direction; the latter would add a strategic control and steering mechanism.[23]

Like the AA predictor's sites guided through feedback, the direction of city planning is subject to "devices", one providing "direction" and the other a "control and steering mechanism." Rodwin elaborates a cybernetic vision of planning in which the feedback of information provides a self-regulating planning mechanism:

> Coordinating and analytical devices can…be created at the national and regional level to feed back relevant information to…regional pressure points in the decision making process and thus help to improve the general performance. An advantage of the system is that it sets up some interlocking self correcting elements which adjust simply to existing institutions.[24]

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[19] Deutsch and Wiener to the editor, *Life*, 18 December 1950, in Box 9, Folder 132, Wiener MS (MC 22), IASP.
[20] Norbert Wiener, Karl W. Deutsch, and Giorgio de Santillana, "The Planners Evaluate Their Plan," *Life*, December 18, 1950, 85.
[21] Ibid.
[22] Karl Deutsch, "On Social Communication and the Metropolis," in *The Future Metropolis*, ed. Lloyd Rodwin (New York: George Braziller, 1960), 129.
[23] Lloyd Rodwin, *Linking Economic Development and Urbanization Policy in Developing Areas* (Cambridge, MA.: Dept. of City and Regional Planning, MIT, 1957), 3.
[24] Ibid.,16.

Information is selected through "devices" and processed through self-regulating feedback such that human decision making mirrors the processes of cybernetic technologies. In additions, regions are said to have "pressure points", like positions on a living body. Cities are still compared to organisms, but planning becomes a concern with the organization of information.

Also in the mid-1950s, the Head of MIT's Department of City Planning, Fredrick Adams, wrote in *Urban Planning Education in the United States*, an assessment of existing planning departments and the needed direction for future changes, that

> There is increasing recognition by leaders of public opinion that new methods of guidance and control over the physical form of our rapidly expanding metropolitan areas must be developed if such areas are to meet reasonable standards of economic and social stability and visual attractiveness.[25]

"Guidance" and "control" were expressions used to explain the workings of the early antiaircraft gunnery in whose development Wiener was decisive. Human planning and technological procedures come to mirror one another through a new founding discourse of cybernetics.

This discourse of cybernetics too entered the documents for a proposed research center. MIT planning Professor Louis Wetmore's 1953 proposal for a research center contends that research must be conducted into "the objectives of those making the decisions which set the physical environment."[26] Note that this approach is unlike, for example, the layouts of Patrick Geddes communal towns, Ebenezer Howard's garden cities, or CIAM's "four functions" of dwelling, work, recreation, and transportation. These latter approaches begin with specific relations of spatial content, of distributions of green space and density. For the Joint Center's advocates, planners are first to research what these objectives are to be.

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[25] Roger L. Geiger, *Research and Relevant Knowledge: American Research Universities since World War II* (New York: Oxford University Press, 1993), 1.

[26] "The Three-dimensional Urban Environment," Oct 7, 1953, 9, Box 49, Folder 6, AC 4, IASP.

Research into the process of city planning for Wetmore is the "creation of new forms and patterns for certain set objectives, and their subsequent testing in the light of these objectives."[27] Thus there are three stages. In the first stage, objectives are selected as informational inputs to the second stage of the process of creating new urban "patterns." The planning process is thirdly tested relative to these pre-selected inputs. In short, information is selected to be processed in the manner in which the AA predictor operates, assessed relative to the difference between the current state and the goal state.

Note that in equating information with energy, Wiener additionally developed a correspondence between the nervous system and electronic computers. Computer inputs and outputs are the result of "artificial sense organs" for which information served as feedback to the central control system.[28] "[Computers] lend themselves very well to description in physiological terms. It is scarcely a miracle that they can be subsumed under one theory with the mechanisms of physiology."[29] To quote historian Reinhold Martin, "the degree of antientropic informational organization in cybernetic terms is regulated through feedback, a continuous cycling of information (obtained by artifical "sense organs") back into a system to correct its course, consolidate its form or modify its output"[emphasis original].[30]

Consider Harvard planner Martin Meyerson's definitively cybernetic move. Meyerson believed city planning should be organized by building a self regulating planning organism-machine. Meyerson proposes three functions of city planning. "A Central Intelligence Function" permits the city planning agencies of local governments to gather and disperse information on local market

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[27] Ibid, 10
[28] Norbert Wiener, *The Human use of Human Being*, 39.
[29] Norber Wiener, *Cybernetics*, 43.
[30] Reinhold Martin, *The Organizational Complex*, 21.

situations, to "lubricate the process of urban development and achieve many of the main objectives of city planning by facilitating intelligent individual actions."[31] "A Pulse-taking Function" implies "the planning agency should perpetually scan the community for indications of maladjustment such as failures of firms, increased congestion." "A Feed-back Review Function" is a means of maintaining a "constant feed back of information on the effects of our projects and proposals so that we can adjust our future programming and planning." As the architecture of the IBM 704 - memory, central processing unit, information input and output devices - and Wiener's neuron computer, the flow of information oils the planning-brain. Like the circular sweep of radar, scanning warns against "maladjustment" and "congestion." The feedback regulates and predicts planning's future path. This focus on selection and processing helped blur distinctions between technology and organism, for which information turned as the founding stance.

Moreover, as a technology for the organization of information, concern with a systematic mechanism for city planning overrode earlier considerations of city planners. Amongst other MIT planners as well, the organic nature of cities was reonceived in terms of information. For example, for MIT planning Professor Walter Isard, during the 1950s the problem of the city as an organism was seen as a problem of an organized network: "I like to view the region as an organic whole complexly interrelated with other regional entities and embodying internally an intricate network of interconnections."[32] He maintained an organic view of the city, but this nature was networked though information, through data: the same spatial arrangement and movements as "circulation patterns" could be viewed as "communications phenomena" and "could be described as certain

[31] Martin Meyerson, "Keynote Address," in *American Institute of Planners, A Report of the Proceedings: the 39th Annual Meeting of the AIP, Providence, R.I., May 6-9, 1956*, 16.
[32] Walter Isard, "Regional Science and the Concept of Region," Regional Science Association: Papers and Proceedings, Second Annual Meeting, December 1955 (Cambridge: RSA, 1956): 22.

statistical distributions."[33] Resultantly, city's specific materiality was evacuated in favor of a systematic mechanism for the organization of information.

Note that the 1954, second edition, of Wiener's *Human Use of Human Beings* contained a chapter titled "Organization as the Message." Wiener wrote:

> A pattern is a message, and may be transmitted as a message. How else do we employ our radio than to transmit patterns of sound, and our television to transmit patterns of light? It is amusing as well as instructive to consider what would happen if we were to transmit the whole pattern of the human body, of the human brain with its memories and cross connections, so that a hypothetical receiving instrument could re-embody these messages in appropriate matter, capable of continuing the processes already in the body and the mind, and of maintaining the integrity needed for this communication.[34]

As Martin comments,

> What differentiates this cybernetic notion of the organism from its nineteenth-century predecessors is not so much the idea of the pattern as such, nor the flux of matter passing incessantly through this pattern, but rather the pattern's newly acquired status as "message." Ultimately, the organism's identity…is not based on its flesh, its material body, but on a materially transmissible body of information.[35]

In Isard, the organic patterns of the city were convertible with informational message. This not only redrew conceptions of the organic and the socio-cultural of cities such that each was seen in terms of data,but the nature of the urban area was guised as information. In turn, this permitted the evacuationof a prior discourse of specific spatial layout, such as concerning parks or roadways, in favor of a cybernetic stance concerning systems of information.

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[33] Ibid., 18.

[34] Norbert Wiener, *The Human use of Human Beings; Cybernetics and Society*, 2d rev. ed., (Garden City, N.Y.: Doubleday, 1954), 96.

[35] Reinhold Martin, *The Organizational Complex: Architecture, Media, and Corporate Space* (Cambridge, MA: MIT Press, 2003), 24.

Operations Research in City Planning

The role of operations research (OR) in this mangle is pertinent as well. OR began in England in 1937 as an application of probability theory to a nascent radar air defense system. As a means to track both allied and enemy aircraft, radar promised to maximize the protection of British fighters. To achieve this required a new tactic of organization around a new technology, demanding coordination between military users, Royal Air Force headquarters and air bases.[36]

By the early 1940s, under the National Defense Resource Council, mathematicians at numerous universities across the US were engaged in the application of mathematics and probability toward improving the effectiveness of weapons, either through better use of existing ones or the design of new types. This later approach was often termed "systems engineering." Two war OR groups were connected with MIT, the Antisubmarine Warfare Operations Research Laboratory and the MIT Radiation Laboratory.

To note, neither was OR impervious from the reach of cybernetics. For example, in 1953, P.M. Morse, who had been attached to the Radiation Laboratory, defined OR as "the development and application of analytical theories of action, which when tested by experiments can be used to predict within specified limits of error the probable results and costs of any action."[37] Thus the approach to urban planning proposed by MIT and Harvard advocates of an urban research center was indebted to cybernetics and OR.

One of the first book-length texts on the techniques of OR detailed the steps of OR as follows:

1) Formulate the problem;

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[36] Erik P. Rau, "The Adoption of Operations Research in the United States during World War II," in Agatha C. Hughes and Thomas Parke Hughes, eds., *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After* (Cambridge, MA: MIT Press, 2000), 513.

[37] PM Morse, "Background of the Operations Research Office," ORO committee, Nov 3, 1952, Morse Papers, IASC.

2) Construct a mathematical model to represent the system under study - using statistics, probability theory, game theory, simulation, integer programming, linear or nonlinear programming;

3) Derive a solution from the model;

4) Test the model and the solution derived from it;

5) Establish controls over the solution; implement the solution.[38]

Note then Rodwin's approach to city planning from 1957:

> The national urban development plan might start with an evaluation of the goals of the plan, with projections of the probable scale, character and pattern of urban development. Models might be prepared indicating existing and desirable urban systems including the present hierarchical functions and relationships of large, medium sized and small towns. Feasible paths of development could be critically examined taking into account such factors and transportation networks, the resource base, economic potentials, development requirements, investment alternatives and estimated physical and economic effects. Possible obstacles could also be assessed, proposals made to deal with them, and time schedules and priorities established...In addition...the very process of implementation should prove instructive. It will bring to light some unanticipated problems which may require modification of the analytical tools as well as of the goals and programs.[39]

Likewise, a 1957 proposal for an urban research center stated:

> The planning process requires the determination of goals, the formulation of alternatives, the preparation of comprehensive plans and their implementation...their flexibility and adaptability to certain and sudden change, the relationship of control systems to these plans, the procedure for making and revising plans.[40]

Planning changed from fixed blue-print for specified ends to a process, to continual readjustment of goals and guides, cybernetics merging with operations research.

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[38] Ibid., 23.
[39] Rodwin, Lloyd, *Linking economic development and urbanization policy in developing areas* (Cambridge, MA: Dept. of City and Regional Planning, M.I.T. 1957), 5-6.
[40] "The proposed focus of the Center for Urban and Regional Studies, MIT, September 20, 1957," 17, Box 6, Folder "Joint Center for Urban and Regional Studies 2/2," MIT School of Architecture and Planning, Office of the Dean, 1934-92 (AC 400), IASC

Funding Options

Thus far I have attempted to show that by the mid 1950s, several members of the MIT and Harvard planning deparments were articulating a cybernetically-infused discourse. Yet why essentially should one care? It is significant because it provided a new basal discourse - not in terms of cities as organisms but cities as organized networks of information. Furthermore, this discourse was strategically aligned with where the potential for successful funding options resided.

Under the federal urban renewal legislation of the 1940s (namely, Title I of the Housing Act of 1949) restrictions in the federal law directed federal urban renewal aid specifically toward improved housing. Taken from the 1941 proposals made in a pamphlet published by the National Planning Association, *Urban Redevelopment and Housing*, the focus of Title I was to be on "the elimination of slums and blighted areas."[41] The 1949 legislation included a provision for a Housing Research Program. Nearly $2.9 million was allocated, in part to universities, but the majority of the funds went to the study of improved building technology and the program was terminated in 1954.[42] There was only sporadic federal funding for urban research.

The earliest meeting on funding for the eventual Joint Center occurred in late October 1953 at the Office of Defense Mobilization (ODM). Reginald Isaacs, Head of Regional Planning at Harvard, Burnham Kelly and Louis Wetmore of City Planning at MIT met with ODM officials to discuss a program for research into necessary changes in the physical layout of urban areas to meet defense requirements.[43] A memorandum of the meeting, of unknown authorship, records ODM administrator Arthur Flemming stating that "the needed research should be largely foundation

[41] Nelson Goodman, *The Languages of Art* (Indianapolis: Bobbs-Merrill, 1969).
[42] Peyton Stapp, Helen Wood, Thomas G. Hutton and Lawrence A. Sternberg. "Federal Statistical Activities." *The American Statistician* 7, No. 4. (Oct., 1953), pp. 3-6, p.5
[43] (2) oct 27, 1953 "record memorandum" AC 4, Box 49, Folder 6

supported" as "strict Federal Budget limitations at the present time and in the foreseeable future would not make possible adequate funds to support the needed research."[44]

Research in the physical concerns of planning was between funding umbrellas. As Martin Meyerson, the first director of the Joint Center would gripe in 1954:

> City planning agencies and the profession itself have not had funds available as grants...Often when the researcher gets funds which can be used for city planning, they are "bootlegged", i.e. the grant may be for some aspect of public health defined broadly enough to include city planning.[45]

City planning was, however, qualified to apply for foundational funds.[46] A program for research that was specifically open to planning concerns did not crystallize until the advent of the Ford Foundation's Program for Urban and Regional Problems in the later 1950s.

Although research in American universities in the 1920s depended on private foundations, total foundation grants in the United States from 1945 to 1952 was less than during the later 1930s.[47] Yet, by the early 1950s the Ford Foundation began offering grants nationally, and its total grants of 66 million were 40% of all foundation giving by 1953. The majority of these grants were to institutions of higher education.[48] By the mid 1950s, its grants were three times those of the Rockefeller and Carnegie combined.[49] It was also the only major foundation to fund a program meant to specifically address urban "problems."

In 1957, the Joint Center advocates turned to the Ford Foundation for financial support. Paul Ylvisaker, associate and later director of the Ford Foundation Public Affairs Program was the Joint

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[44] (1) oct 27, 1953 "record memorandum" AC 4, Box 49, Folder 6

[45] Martin Meyerson, "Research and City Planning," *Journal of the American Institute of Planners* 20, no.4, (Fall 1954): 201-205, 202

[46] An example of private funds for urban research was the Spelman Fund.

[47] Roger L. Geiger, *Research and Relevant Knowledge*, 92.

[48] Ford Foundation, *Annual Report*, 1960; Francis X. Sutton, "The Ford Foundation: The Early Years," *Daedelus* 11 6 (Winter 1987): 41-91.

[49] Figures taken from *Research and Relevant Knowledge*, 92-93.

Center advocates' main contact at the Ford Foundation. The Program in Urban and Regional Problems (URP) was administered under the Public Affairs Program. URP's existence was largely due to Ylvisaker's efforts.[50]

Ylvisaker was active in the contemporary planning discourse and spoke at numerous urban planning conferences.[51] A few comments of Ylvisaker's are worth considering. At one conference in the late 1950s, he offered that in planning, "the essential condition is that ...the community is provided with an explicit statement of goals, a sense of direction, and a listing of priorities among choices to be made and steps to be taken."[52] First the goals must be stated, appropriate information must be selected. To attain these goals, Ylvisaker sees the city as a system. A few years later he states that he "look[s] at the urban community not as a miscellany of people, places and problems - but as a *system.*"[53]

A Ford Foundation "Report on the Urban (Metropolitan) Program" provides some guidance on the aims of URP and the Ford Foundation's agenda for cities under Ylvisaker (see Figure 2.9). Overall, the desires of URP and the JCUS instigators were generally aligned. In a letter to President Stratton, Rodwin reports: "Ford's original guidance in this field came from a panel of five, two of whom were then in the M.I.T. Department of City and Regional Planning and a third was a former member of the Harvard faculty."[54]

The "Report" begins by stating:

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[50] Virginia M. Esposito, ed., *Conscience and Community: The Legacy of Paul Ylvisaker* (1999).
[51] For example, he spoke at the 1956 meeting of the Regional Science Association, and the "Conference on Metropolitan Problems"in Berkeley in1958.
[52] Paul Yvislaker, "Administrative considerations in regional planning," in Virginia M. Esposito, ed., *Conscience and Community*, 81
[53] Paul Yvislaker, "Community action: a response to some unfinished business," 14, in Virginia M. Esposito, ed., *Conscience and Community.*
[54] Letter from Lloyd Rodwin to Julius Stratton, Feb 11, 1959, 4-5, Box 6, Folder "'1958 2/2," AC 400, IASC

> The purpose of the Foundation's urban program is to mark out strategic points at which the problems of rapid urban growth can be manageably and productively attacked.[55]

Referring to urban "problems" was nothing new. For example, a formative statement of urban problems is found in Jose Luis Sert's *Can Our Cities Survive? The ABCs of Urban Problems* in the early 1940s.[56] Expanded from the efforts of the Fourth (1933) and Fifth (1937) Congresses of the CIAM, the problems of cities and their solutions are structured around the "four functions" of the city as set out in the "town-planning chart" from the 1933 fourth CIAM congress. Dwelling is inhibited by overcrowding, recreation is hampered by insufficient open space, work places are not situated proximally according to their functions (such as industrial or commercial), and transportation is beset with congestion.[57] For Sert and CIAM, the specific city planning solution is based in specific changes to the city structure, and the selection of urban solutions is inseparable from processes of urban planning.[58] This is not the approach that would dominate the urban center disciplinary paradigms on research: Goals are embedded in formal concerns. In other words, this cannot be viewed in terms of the use value of information processing machines, in terms of information selection and subsequent processing.

To return to the Ford Foundation "Report," past research attempts are accused of being "disconnected," "sporatic," and generally of poor quality.[59] Again, this is what the founders of the Joint Center contended: As early as the first documents of proposal, Wetmore's 1953 "The Three

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[55] Ford Foundation , "Report on Urban (Metropolitan) Program," Oct 8, 1957, 1, Box 6, Folder "OK AC 400 B.6," AC 400, IASC

[56] José Luis Sert, *Can our Cities Survive? an ABC of Urban Problems, their Analysis, their Solutions* (Cambridge, MA: Harvard University Press, 1942), 2.

[57] Ibid., 246-248.

[58] Although Sert refers to "research" and "the field of statistics and its employment as a scientific method," this research is achieved through maps which were to indicate land use, city functions by area and their relationships, or "city radiographs." Ibid., 6.

[59] Ibid., 9,10, 12.

Dimensional Urban Environment," Wetmore refers to "fragmentary concepts of desirable urban form" that "are based partly on intuition and are the centers of controversy."[60] Architects and planners "are only now beginning to turn to research to provide the desperately needed information, criteria and techniques."[61] The Center is to provide a necessary "systematic" research to remedy to this paucity.[62]

According to the "Report," urban areas are shaped by a complex of forces: it is "basic forces - social, economic, political and technological - which underlie modern urban development."[63] Yet because these forces form a system, the methodology for solving a system of equations provides a methodology to solve urban problems. For urban development,

> Some understanding can be conveyed of the forces of industrial and population growth which have created modern urbanism, the social habits which give it form, and the simultaneous equation of economic, political and social factors which show the way to the solution of its problems.[64]

The problems of the city are seen as solvable by a simultaneous equation. Solving this equation means solving the problems of the city. Where the alignment between the Ford Foundation and the Joint Center advocates would fail is in the proposal of the "Report" of "relating (even subordinating) physical to social planning."[65]

Here the tensions between Ford and the Joint Center founders can be seen. For the Ford Foundation's Urban Program, "a specific objective is to re-define planning."[66]

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[60] Ibid., 2-3
[61] Ibid., 3.
[62] Ibid., 2.
[63] Ibid., 7.
[64] Ibid, 12.
[65] Paul Yvislaker, "Community action: a response to some unfinished business," 17, in Virginia M. Esposito, ed., *Conscience and Community.*
[66] Ford Foundation , "Report on Urban (Metropolitan) Program, Oct 8, 1957," 1.

our present schools of planning...are in most cases oriented to architecture and landscape planning; their emphasis is on the aesthetic, spatial and physical aspects of urban development...But the requirements of planning for urban development in our times go far beyond this one set of interests and skills; economists are also needed, and so are political scientists, traffic engineers, sociologists, public administrators, geographers, communications experts.[67]

Meyerson wrote that Ylvisaker urged that "the Foundation staff believes the real test of the new Harvard-M.I.T. venture will be its success in involving representatives from disciplines not previously engaged in urban research." [68] Rodwin recorded that during a meeting at the Ford Foundation,

> Ylvisaker hinted that the right way to handle urban problems was to bring together first rate minds of social scientists in different fields. Howard and Rodwin emphasized that this point of view, very reminiscent of Harvy Perloff's doctrines, would overlook the fact that physical orientation of the environment would be omitted, and that no social scientist could handle this responsibly.[69]

Economist and head of the University of Chicago Planning School during the early 1950s, Harvey Perloff's "doctrines" were that economic and social impediments to improving urban conditions must be addressed first and foremost. For example, in his 1950 publication *Puerto Rico's Economic Future*, he asserts that "accustomed living standards, desire for self-improvement, job security and family security, sense of family and social responsibility, competitive drive, pride in workmanship, value placed on leisure" are the major forces impeding improved urban existence .[70] In other words, this is social planning (or, more accurately social engineering).

In addition, sociologists such as Herbert Gans in his work in the West End of Boston to interpret the impact of urban renewal on residents, and the joint efforts of economists and

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[67] Ibid., 7.
[68] Memorandum to Files from Martin Meyerson, June 13, 1958, ,1,Box 6, Folder "'1958 2/2," AC 400, IASC
[69] Memorandum to Files from Lloyed Rodwin, 2, Box 6, Folder "OK AC 400 B.6," AC 400, IASC
[70] Harvey Perloff, *Puerto Rico's Economic Future, a Study in Planned Development* (Chicago: University of Chicago Press, 1950), 248.

sociologists at the University of Chicago to investigate the conditions of city life had begun to steer the academic study of cities away from concerns with urban form. Repeatedly in the negotiations with the Ford Foundation the Joint Center's founders reiterated that focus must be on the physical form of the city, so as to preserve their role in the wash of social scientists beginning substantially to engage urban concerns. It required a careful balancing between interdisciplinarity and a focus on urban form over broader social planning. Yet this urban form was to be generated through formal devices provided by cybernetics and operations research. This formal device provided pattern as message - city materiality was reformulated in terms of formal mechanisms for the organization of information in terms of selection and processing. To accomplish this, the Joint Center advocates turned to arguments concerning basic research.

Basic Research

As numerous scholars have shown, MIT's current research practices were largely formed through the defense contracts of World War II and the industry liaisons after. This careful balance between the liquidity benefits of external industry and governmental funding against the programmatic concerns of the sponsors is a formative tale of MIT's research practices.[71] Perhaps the most famous individual to express concern with this allocation of power was Vannevar Bush. Bush was Dean of the MIT School of Electrical Engineering when he left in 1940 to head the National Defense Resource Committee (NDRC).[72] The NDRC became the earliest example of a much

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[71]The standard work is Stuart W. Leslie, *The Cold War and American Science : The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993.; see also Geiger, *Research and Relevant Knowledge : American Research Universities since World War II*, 411.

[72] Bush left MIT in 1940 to chair the National Defense Research Committee, coordinated the Manhattan project as Director of the Office of Scientific Research and Development and served as President of the Carnegie Institution of Washington from 1939 to 1955

replicated model for basic research. The new organization was to be under the control of scientists and fully independent for the purposes of research.[73] Scientists and engineers conducted research and worked with representatives from the armed services, but were free from administrative concerns, thereby permitting, in the words of historian A. Hunter Dupree, "the exercise of scientific choice in the hands of scientists, who alone were in a position to judge the merits of a given line of research."[74] Moreover, contracts were restricted to research and development only. The NDRC specified it was the research rather than a documentation of specific findings the government was purchasing, thereby increasing scientists' flexibility in pursuing research projects.[75] By the time the Joint Center advocates were soliciting for funds, this model had become the norm of conduct among much governmental and foundational sponsorship.

Bush got the opportunity to publicly advocate for this model of basic research in 1944, when President Roosevelt requested a report soliciting recommendations on how "the information, the techniques, and the research experience" gained by scientists in the war effort could be translated into improving the health and welfare of the nation during peacetime.[76] In July of 1945, Bush completed Roosevelt's requested report, giving it the title *Science: The Endless Frontier.* Bush's definition of basic research is worth quoting at length, as the structure of privilege he assigns to basic over applied research manifests integrally in the negotiations over urban design research autonomy at

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[73] Vannevar Bush, *Pieces of the Action* (New York: Morrow, 1970), 34-35; Nathan Reingold, *Science, American Style* (New Brunswick: Rutgers University Press, 1991), 284-333.

[74] A. Hunter Dupree, ""The 'Great Instauration' of 1940: The Organization of Scientific Research for War," in Gerald Holton, ed., *The Making of Modern Science* (New York: Norton, 1 972.), 443-67. See also Irvin Stewart, *Organizing Scientific Research for War: The Administrative History of the Office of Scientific Research and Development* (Boston: Little, Brown, 1948).

[75] Erik P. Rau, "The Adoption of Operations Research in the United States during World War II," 61.

[76] United States. Office of Scientific Research and Development and Vannevar Bush, *Science, the Endless Frontier; a Report to the President on a Program for Postwar Scientific Research* (Washington: National Science Foundation, 1960), 4.

MIT and Harvard the following decade:

> Basic research is performed without thought of practical ends. It results in general knowledge and an understanding of nature and its laws. This general knowledge provides the means of answering a large number of practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers. The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic research were long neglected.... Basic research leads to new knowledge...New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science.[77]

Science was a carefully reasoned justification for the key role of basic science. Applied science is assigned use-value, but basic research is what provides its possibility.

Bush explicitly called for "Centers of Basic Research" at universities and endowed research institutes, to be "free from the influence of pressure groups, free from the necessity of producing immediate results, free from dictation by any central board."[78] The lasting institution of Bush's *Science* is the National Science Foundation. Although much weakened in powers from his original conception, when the National Science Foundation Act of 1950 passed, it was chiefly concerned with basic scientific research in institutions of higher education.[79] From 1952 to 1958 sixteen research universities received $25.4 million or 43% of total NSF research grants. MIT received the fourth largest allocation, at just over 2 million.[80]

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[77] Ibid., 16.

[78] Ibid.

[79] J. Merton England, *A Patron for Pure Science: The National Science Foundation's Formative Years* (Washington, D.C.: NSF, 1982), 113-28; John T. Wilson, *Academic Science, Higher Education, and the Federal Government, 1950-1983* (Chicago: University of Chicago Press, 1983), 10-11.

[80] J. Merton England, *A Patron for Pure Science*, 259.

In the words of historian Roger Geiger, the director of the new foundation, Alan Waterman became, "the principal spokesman for the virtues of basic research."[81] Waterman's speeches and the Foundation's *Annual Reports* became platforms for these invocations.[82] Urban planning as a discipline did not benefit from these allocations since, not a natural science, it was not initially qualified for applying for NSF funds. Nevertheless it was not unaffected by the call for basic research.

At a 1953 National Planning Association conference attended by Rodwin and Howard, NSF director Alan Waterman spoke on "The Role of Government and the Coordination of Basic Research." At a 1955 conference attended by Wetmore, Howard presented a paper on "Basic Research Problems of the Urban-Metropolitan Region."[83] Howard's 1953 draft for a research center in urban planning drew upon the ideology of basic research in making the case for funding:

> immediate applicability in terms of current political, social, or economic climate may be irrelevant to a course of exploration leading to the wisest long range decisions in guiding growth and development...This is an invitation to work in the direction of the theoretical or abstract...It might...rule out an "applied" research undertaking [emphasis original].[84]

The call for basic research was heard throughout the years of attempts at founding a research center. For example, in a letter from Rodwin to MIT President Julius Stratton in 1958, Rodwin writes:

> Universities such as ours are most apt to make their contributions in basic research of which there is an acute need in the field of urban studies. We believe it is proper for the major emphasis of universities to be in this direction.[85]

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[81] Geiger, *Research and Relevant Knowledge* (New York: Oxford University Press, 1993), 159.

[82] NSF, *Annual Reports,* 1950-51, 3-12; 1951-52, 5-7; 1952-53, 1-8; Alan T. Waterman, "Research for National Defense," *Bulletin of the Atomic Scientists* 9 (1953): 36-39; Alan T. Waterman, "Government Support of Research," *Science* 10 (1949): 701-7.

[83] Joint Conference of the Committee of New England of the National Planning Association and the American Association for the Advancement of Science. For reprints of conference speakers, see Walter Isard, *History of Regional Science and the Regional Science Association International: The Beginnings and Early History* (Berlin ; New York: Springer, 2003), 64-68, 107.

[84] John Howard, "Proposed Policy on Scope and Organization of Urban Research," Feb 4, 1953, 3, Box 4, Folder "research-miscellaneous ½," AC 400, IASC.

[85] Letter from Lloyd Rodwin to Julius Stratton, Feb 11, 1958, 8, Box 6, Folder "1958 2/2," AC 400, IASC.

To avoid the applied orientation of the Ford Program Urban and Regional Program, and to shun being called into specific urban problems, the Joint Center's founders consistently referred to the need for basic research. In drawing on basic research, the founders also refused to follow a suggestion by Ylvisaker that the Center follow a "case study" model, such as was pioneered by the Harvard Business School, in which specific issues that had occurred in business were collectively analyzed.[86] The applied idea of this approach was something for which the founders had no interest.

In the claims for a research center in urban studies, rehearsed are the points established by Bush in *Science*. Basic research lacks immediate applicability but is necessary for long term advances and universities are the appropriate locus for basic research. Just as social scientists in the late 19th century turned to the established natural sciences to generate their own claims of legitimacy, it is significant that urban planners are construed as scientists in a laboratory. Wetmore's 1953 edition stated: "using the Boston area as a laboratory contributions can be made to basic research."[87] *Design* ranges in meaning from purposeful act, a partial sketch for future realization, an imprinted pattern; *Planning* is even more expressive of ends intended. Nevertheless, this ideology of basic research in urban planning would serve as a fundamental point of leverage against the burgeoning center being bound to programmatic concerns.

Interdisciplinary Centers

When the URP was implemented, the majority of the research funded was to study the "urban problems" specific to particular metropolitan areas such as New York, Detroit and Pittsburgh.

[86] Memorandum from Lloyd Rodwin to Julius Stratton, Feb 11, 1958, Box 6, Folder "'1958 2/2," AC 400, IASC
[87] "Research Program - Department of City and Regional Planning," Feb 4, 1953, 1, Box 2, Folder "Research Miscellaneous 2/2," AC 400, IASC.

However, there was an interest from Ford in funding a basic research center, that "there is need for basic research in many subject matter fields and in many places." [88] They were hoping to sponsor

> at least one university center of urban affairs [which] will concern itself with the very long view of urban development and with bringing technological and social research on urban problems into close relation.[89]

In the First *Annual Report* of the National Science Foundation, chairman James Conant, made the distinction between "programmatic" and "uncommitted" research.[90] The former was, whether basic or applied, directed by the interest of a particular agency, the utility of results for the agency paramount. The latter was disinterested, emergening from pressing disciplinary questions. Uncommitted was more likely to apply to basic research, although not commensurate[91] - as historian Paul Forman notes, "in truth, only a small fraction of ... R&D funds labeled basic research went to support investigation that could reasonably be called fundamental. [92] Programmatic research tended to correspond with organized, externally funded, university research.

Within the disinterested-interested, disciplinarily motivated-federal contract continuum, the Joint Center's proposal fell somewhere in the middle. They chose to call themselves a Center. In the early 1960s, Harvard president Nathan Pusey described a "center" as "an administrative device for assembling scholars from different disciplines and departments around a shared interest. Centers are means for facilitating interdisciplinary assaults on complex fields of investigation."[93] At centers, the research tended to fit the disciplinary-driven questions, but it was funded by nonacademic interests. Two models for research formative to the Joint Center, two ways in which OR and cybernetics served

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[88] Ford Foundation , "Report on Urban (Metropolitan) Program," 10
[89] Ibid., 2.
[90] James B. Conant, "Foreward" in National Science Foundation, First *AnnualReport, 1950-51,* viii.
[91] James B. Conant, *Science and Common Sense* (New Haven: Yale University Press,1950), 3I7-24.
[92] Paul Foreman, "Behind Quantum Electronics: National Security as Basis for Physical Research in the United States, 1 940-1960," *Historical Studies in the Physical and Biological Sciences* 18 (1987): 216.
[93] Harvard University, *President's Report,*1962-63, 8.

as background contexts for the Joint Center, were the Research Laboratory of Electronics (RLE) and the Center for International Studies (CIS). At the RLE Wiener in part developed wartime weapons contributions that would lead to cybernetics.[94] The CIS was an exemplar of OR in practice.

The RLE was MIT's first interdepartmental laboratory. On the occasion of its twentieth anniversary, one of its alumni, Julius Stratton, who would be MIT President during the Ford negotiations, inventoried its contributions to MIT as follows:

> The founding of the new electronics laboratory in 1946 represented a major new departure in the organization of academic research at M.I.T. and was destined to influence the development of interdepartmental centers at the Institute over the next two decades. These centers have been designed to supplement rather than to replace the traditional departmental structure. They take account of the fact that newly emerging fields of science commonly cut across the conventional disciplinary boundaries. And they afford a common meeting ground for science and engineering, for the pure and applied aspects of basic research, to the advantage of both. Perhaps more than any other development in recent years they have contributed to the special intellectual character and environment of M.I.T.[95]

In 1947, the RLE budget, when added to other research contracts, made MIT's postwar research budget ($8.3 million) nearly double its academic budget ($4.7 million).[96] The preponderance of funding from research would remain normative.

The organization of the CIS, however, had a more direct impact on the organization of the Joint Center. In spring 1950, the Soviet Union had figured out how to jam the Voice of America, a broadcast of pro-United States propaganda. The State Department approached MIT President James

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[94] Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21, no. 1 (Autumn, 1994): 240.
[95] Julius Stratton, "RLE: The Beginning of an Idea," in *RLE, 1920-1946* (Cambridge, 1966), 6.
[96] Figures from Geiger, *Research and Relevant*,.63. For the overall development of MIT, see Richard M. Freeland, *Academia's Golden Age: Universities in Massachusetts, 1945-1970* (New York: Oxford University Press, 1992), 123-78.

Killian hoping the Institute would conduct a study on how to best "get information into Russia."[97] MIT accepted. Project Troy, as it was named, was revolutionary in its interdisciplinary methodology, involving engineers, natural and social scientists.[98] It was, more specifically, a fine example of operations research in practice.

After the project was completed, Killian called for a permanent research center, and the CIS was created in January 1952. Max Milkman, director of the CIA and MIT economist, was placed in charge.[99] The CIS obtained $875,000 from the Ford Foundation in seed money. The 1952 Ford Foundation Annual Report proudly announced the interdisciplinary model of this study: "Research will be done by a group of analysts with different professional backgrounds, including anthropologists, sociologists, psychologists, historians, economists, lawyers, political scientists, and natural scientists."[100]

In 1957, Lloyd Rodwin sought advice from Milkman on how to organize the center and tips on how to propose the research idea to funding sources. Milkman offered him details such as how to account for overhead and what combination of visiting and permanent faculty members seemed to work best, and most significantly, how to tailor the grant-writing to permit the greatest academic freedom in accordance with the sponsoring agency.[101] The organizational model of the CIS was

[97] Nils Gilman, *Mandarins of the Future: Modernization Theory in Cold War America* (Baltimore: Johns Hopkins University Press, 2003), 156.
[98] Ibid., 157. Panels were assembled to provide an overview of potential techniques for dealing with specific propaganda problems. The entire group discussed these surveys, which would then move to smaller groups of technical specialists. These specialist groups produced reports, which were then reviewed by the entire group. An editorial committee then prepared a penultimate draft, and a last group review produced a final report.
[99] Donald Blackmer, *The MIT center for International Studies: the Founding Years*, 1951-1969 (Cambridge: MIT Press, 2002).
[100] Ford Foundation *Annual Report* 1952, 53. The Rockefeller and Carnegie Foundations also contributed over the next decade. Ibid., 158-159.
[101] Memorandum from Lloyd Rodwin to Files, Oct 18, 1957, Box 6, Folder "OK AC 400 B.6," AC 400, IASC.

clearly the type of operations research-inspired approach which Rodwin hoped the Joint Center would emulate, and the interdisciplinary prescient held Ford's full endorsement.

Finally Founded

The JCUS advocates desired to establish a basic urban research center. It is questionable the extent to which they desired an interdisciplinary center or the extent to which this was a concession to the funding source of the Ford Foundation. At any rate, the fiscal campaign was successful although the final negotiations over funding were rather tedious. Originally, each Harvard and MIT wanted their own centers, funded jointly under a single grant. The first request was for $3.7 million over five years (nearly $26.6 million in 2006 dollars).[102] These hopes were quickly dashed - this allocation would have absorbed a quarter of Ylvisaker's funds for the program. However, under pressure from Ford on the expense, and for fear of redundancy in research efforts between centers at each school, MIT conceded to unite with Harvard in one endeavor. They ultimately asked for $650,000 over five years. In October 1958 the Joint Center was approved for a grant of $675,000 "for general support, over a period of approximately five years," and opened in April 1959.

The JCUS agreed, in the final application to the Ford Foundation to address the following issues:

1. The Form of the City
2. City Structure and Growth
3. Transportation
4. Housing
5. Regional Physical Development
6. Technology

[102] "Federation Draft," Nov 1957.

7. Public Policies and Controls (although in an earlier version this read as "Control techniques of the physical environment" [103])
8. The Planning Process
9. Social Values
10. Developing Areas
11. The Urban Landscape.[104]

With the exception of perhaps "social values," these items can be skewed to concern the physical form of a city. Although the JCUS's founders maintained a focus on physical city layout, their interest in a systematic planning method evacuated commitments to a specific city form. Pattern as blueprint was turned into message: city planner's concerns were reformulated through a systematic mechanism for the organization of in(form)ation. This systematic planning method was such that decision making in human planners was reconfigured in terms of data selection and processing, thus mirroring the operations of information technologies.

The JCUS's founders concern with a systematic planning mechanism contributed to a redrawing of distinctions between organism, technology and city. Nature and socio-culture were re-envisioned in the terms provided by systems and information technologies. Whereas throughout the 19th and 20th centuries cities had been compared to organisms, now the organic nature of cities was reconfigured in terms of cybernetics, in terms of pattern as message. Socio-cultural urban concerns were reduced to the nature of information and feedback.

Furthermore, the nature of the human and inhuman was reconfigured through aligning human decision making in planning to the operations of information technologies. Even the generality of the above reference to "social values" meant such socio-cultural considerations could be treated with a systematic planning mechanism: goals could be guised as data and means to these goals

[103] "Federation Draft," Nov 1957, Box 6, Folder "'Joint Center for Urban and Regional Studies' 2/2," AC 400, IASC.

[104] "Proposed Focus of the Center," Sept 20, 1957, 4, Box 6, Folder "'Joint Center for Urban and Regional Studies' 2/2," AC 400, IASC.

given in terms of processing of that data. Systems of information became a grounding discourse for these urban planners. This is significant because by aligning planning with the functioning of an information machine and taking this as the basis from which planning was to proceed, it enabled them to carve a disciplinary role for themselves. In many ways the reconfiguration of nature and socio-culture in terms of information was a residual effect of this disciplinary struggle. The next chapter turns to Christopher Alexander's work while associated with the Joint Center.

Chapter 3 - Machines, Humans, Mental Pathology, and Christopher Alexander, 1959-1964

POWELL

I sent that damned robot out five hours ago. When he didn't come back I started tracking him by short wave.

(beat)

He's gone crazy!

DONOVAN

Looks like he's *circling* the selenium pool. Instead of going out and picking up what we need and coming right back he goes close to the pool, then turns around and starts back for the station...

POWELL

But he doesn't go very far. Just starts back for the pool and keeps repeating the runaround, round and round...and we're gonna fry!

CALVIN

You gave him direct orders?

POWELL

(looks at her with dislike)

Of course.

CALVIN

But the Three Laws...a robot can't defy the Three Laws.[1]

This dialogue is from science fiction author Harlan Ellison's screenplay adaptation of Issac Asimov's 1950 collection of short stories *I, Robot*. Dr. Susan Calvin is a robot psychologist who assays dysfunctions of robots. The laws of robopsychology are three:

> One: a robot may not injure a human being or, through inaction, allow a human being to come to harm.
>
> Two: a robot must obey the orders given it by human beings except when such orders would conflict with the First Law.
>
> Three: a robot must protect its own existence as long as such protection does not conflict with the First and Second Laws.

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[1] Harlan Ellison and Isaac Asimov, *I, Robot: The Illustrated Screenplay* (New York, NY: Warner Books, 1994), 107.

When any of these laws are violated the robots in Asimov's tales go insane, run in circles, recite nonsensical statements - even commit suicide.

Since the Second World War, people have been reconceived relative to aspects of computer related media and computer related media reconfigured to assume aspects of humanity. By computer related media I refer to the systems sciences which emerged surrounding WWII war research such as cybernetics, artificial intelligence, and information theory. In the normative case, this effacing of distinctions between humans and these technologies has been well theorized and documented. For example, Donna Haraway proposes that by the late twentieth century humans were already cyborgs, "a hybrid of machine and organism."[2] N. Katherine Hayles offers that we have already become posthuman, a merging of person and technology, when we become part of a "distributed cognitive system in which represented bodies are joined with enacted bodies through mutating and flexible machine interfaces."[3] Additionally, the blurring of animate and inanimate when humans and machines behave ab(norm)ally has been theorized, post WWII, from Isaac Asimov's 1950 *I, Robot* science fiction tales, excerpted above, to recent work treating prosthetics.[4] Yet what has not been considered is how this blurring between human and computer related media has been conceived when humans and technology behave non-normatively in relation to practices and methods of designing. My narrative takes the architect Christopher Alexander's dissertation, published little altered in 1964 as *Notes on the Synthesis of Form* (hereafter *Notes*), as a jumping off point to trace

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[2] Donna Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in *Simians, Cyborgs and Women: The Reinvention of Nature* (New York; Routledge, 1991), p.150.
[3] N. Katherine Hayles, *How We Became Posthuman* (Chicago, Ill: University of Chicago Press,1999), p. xiv.
[4] See, e.g., Marquand Smith and Joanne Morra, eds., *The Prosthetic Impulse: From a Posthuman Present to a Biocultural Future* (Cambridge, MA: MIT Press, 2006).

how abnormality has been portrayed relative to design theory when a discourse of computer related media intertwined with a discourse of psychology (see Figure 3.1).[5]

I choose *Notes* not only because it was the first text to consider how computers could go beyond serving as a rudimentary rendering tool to alter methods and practices of designing.[6] Moreover, *Notes* was not only extremely formative to the Design Methods movement. To suggest its lasting impact, consider that it not only has gone through five editions and remains in print but ranks as the 176,364th best seller on Amazon.com. To compare this figure to other seminal 1960s architectural texts, *Notes* has outsold Colin Rowe's and Fred Cotter's *Collage City* by nearly 100,000 ranks and Robert Venturi's *Complexity and Contradiction in Architecture* by nearly 700,000 ranks. At the time of its publication, *Progressive Architecture* heralded that it "could revolutionize the approach to architectural design."[7] The journal *Industrial Design* stated it was "one of the most important contemporary books about the art of design."[8] The *Journal of the American Institute of Planners* predicted that "it may one day prove to be a landmark in design methodology."[9]

In Chapter Two I argued that machines that transform information provide models for the purposeful actions of urban planning procedures. I argue that in *Notes* a machine that transforms information is proposed to explain the process of designing in non-modern design cultures. Alexander refers to these as "unselfconscious" design cultures. However, in Alexander's portrayal of contemporary1960s design cultures, which Alexander refers to as "selfconscious" design cultures, I

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[5] Christopher Alexander, *Notes on the Synthesis of Form* (Cambridge, MA: Harvard University Press, 1964).
[6] Robert Bruegmann's review of the early use of computers in architecture remains unparalleled in its detail. See Robert Bruegmann, "The Pencil and the Electronic Sketchpad: Architectural Representation and the Computer" in *Architecture and its Image*, eds. Eve Blau and Ned Kaufman (Montreal: Centre Canadien d'Architecture/Canadian Centre for Architecture; Cambridge, MA: Distributed by the MIT Press, 1989).
[7] R. H. Mutrux, "Revolutionary Approach to Design," *Progressive Architecture* XLVI, no. 5 (May 1965): 208.
[8] Malcolm J. Brookes, "Books," *Industrial Design* 12, no.3 (March 1965): 20.
[9] Edward J. Kaiser, "Book Reviews," *Journal of the American Institute of Planners* XXXI, no.1 (February 1965): 84.

contend that the process of designing fails to exhibit the utility of a machine that transforms information. In short, the human designing machine falters due to interventions from intuition. Human designers for Alexander continue to behave as machines, yet as disordered machines deviating abnormally from purposeful design behavior. Alexander allies these failures in designing to psychological pathologies.

Similarity of use may conceal a variety of structures, but this functionalism - in which highly different material can support the same functional organization (or disorganization) - was operative for Alexander. It was also operative in the institutional context in which Alexander was embedded, the Harvard Center for Cognitive Studies (CCS). This is where Alexander was engaged in conducting psychological experiments while additionally pursuing his PhD work at the Harvard Graduate School of Design,. For both Alexander and influential CCS figures, the non-rational was allied to psychological pathologies and psychological pathologies were envisioned applicable to human or machine. Humans were configured as ailing information machines and machines were conceived as pathological humans.

The blurring between human and inhuman applied to cases of malfunction, but did so in terms delineated by the properties of an information machine operating without its intended use value. Mental disorganization was constructed as dysfunction of information storage, selection, transmission, and processing. The separable function of information selection, storage, transmission, and processing is important because this segments the world into compartments of data. The treatment for this malfunction, by Alexander and affiliates of the CCS, supports a normative view of mental disorganization as pathological. Cultural adaptability and social norms were then, in Alexander, enlisted to cure the diseased information machine that was the designer. These norms were, I argue, to return the designer to his or her proper instrumental functioning as always having been a machine, free of disorganization and mental disorder, which transforms information.

These views of Alexander and the CCS forged a machinic view of design that allied with an institutional push to enforce machinic norms of purpose as use value. The parallel of function in terms of use value and dysfunction in terms of failed use value enforced a space of correction which saw abnormality and mental disorganization as undesirable. Mental disorder was doubly unwanted because it violated existing norms of normalcy and was explicitly not purposeful, not useful.

Alexander's Ashby

In 1960, the chair of Alexander's Ph.D. committee at Harvard, John Coolidge, requested from the psychologist Jerome Bruner, co-founder of the CCS, a "general estimate" of the quality of Alexander's dissertation. Bruner responded:

> I am struck by the parallel between what Mr. Alexander is doing and what Ross Ashby does in his *Design for a Brain*, a work often cited in the footnotes. Both are programmatic notes on the formal properties of a complex process -- Ashby toward the brain and its design, Alexander toward the design of a living space.[10]

Design for a Brain (hereafter *Design*) was published in 1952 by biochemist, neurophysicists and cybernetician William Ross Ashby (see Figure 3.2).[11] This text serves as an elaborate justification of an electromechanical apparatus Ashby built, named the homeostat (see Figure 3.3, 3.4). The homeostat, operating through a collection of magnets, relays and electrical circuits, was to explain the principle which makes homeostasis, or the condition of organism stability in light of disruptions from environmental conditions, possible. Homeostasis was to capture the development of an individual

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[10] Letter from Jerome Bruner to Norman T. Newton, December 29, 1960, 2, Box 1, Papers of Jerome Bruner, Correspondence, 1961-1962, (HUG 4242.5), Harvard University Archives

[11] William Ross Ashby, *Design for a Brain; the Origin of Adaptive Behaviour* (London: Chapman & Hall, 1952).

organism's adaptation to its environment. When introduced by the physiologist Walter B. Cannon in the late 1920s, homeostasis initially applied to solely living matter. [12] However, to consider homeostasis as a means to think regulation between human and non-human after WWII became a common proposal in the design community. The artist László Moholy-Nagy, the historian Siegfried Gideon, the visual designer Gyorgy Kepes, and the architect Richard Neutra also saw homeostasis in this role, as a way to think controlled organization between the human and the designed environment. [13] Ashby, however, particularly considered homeostasis universal to human and machine.[14] This is significant because the manipulation of inanimate simulations became equivalent with the manipulation of animate phenomenon. In this manner human and nonhuman were equaled in Ashby.

The goal of the homeostat is internal stability in light of environmental change or stable adaptation in fluctuating external conditions. The homeostat operates on two levels and resists two orders of environmental disturbance. One level is when a selected electrical input current is driven outside an acceptable limit. This current is to simulate when "small, occasional, and random disturbances" occur. [15] In this case, the current change induces a feedback process (or, the return of a fraction of the output signal to the input) to return the current to acceptable limits and restablize the

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[12] Walter B. Cannon, "Physiological Regulation of Normal States: Some Tentative Postulates Concerning Biological Homeostatics," in *Jubilee volume to Charles Richet*, ed. Auguste Pettit (Paris: Editions Medicales, 1926): 91-93.

[13] László Moholy-Nagy *The New Vision*, (New York: Wittenborn, Schultz, Inc., 1947), passim.; Siegfried Gideon, *Space, Time and Architecture*, 3rd ed. (Cambrige, MA: Harvard University Press, 1954), 432. Richard Neutra, *Survival through Design* (New York: Oxford University Press, 1954), 317,327; Richard Neutra, "Inner and Outer Landscape," in *The New Landscape in Art and Science*, by Gyorgy Kepes (Chicago: Paul Theobald, 1956), 84; Gyorgy Kepes, *The New Landscape in Art and Science* (Chicago: Paul Theobald, 1956), passim. See also Reinhold Martin, *The Organizational Complex: Architecture, Media, and Corporate Space* (Cambridge, MA: MIT Press, 2003), Chapter 1.

[14] William Ross Ashby, "Homeostasis," in *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems*, vol. 9, ed. Heinz von Foerster (New York: Macy Foundation, 1953), 73.

[15] William Ross Ashby, *Design*,146.

machine. On another level, if a larger environmental disturbance occurs - registered in the form of a larger current change - a relay trips and, by selecting from a table of random numbers (to determine the value of circuit resistance), the device randomly reconfigures itself again employing feedback in the process. The homeostat selects information from the environment in the form of electrical currents. It transmits and processes information in the form of circuit resistance and feedback to attain a homeostatic state. It transforms information because an electrical current communicates environmental changes to the machine to which the machine then responds.

Turning to Alexander's mobilization of the homeostat, Alexander saw the goal of design as homeostasis, or adaptive fitness between a designed form and its environmental context. Again, this was not an uncommon proposal among the design community in the mid 20th century. Yet specifically, in Alexander's "unselfconscious" design cultures, on one level, a form maker can perform small design changes.[16] Alexander offers the example of patching a hole in an igloo to regulate its internal temperature.[17] These are referred to as "error-correcting" variations to a form.[18] Similarly, Ashby provides an architectural parallel of "variation-limiting" measures in the homeostat in response to "small, occasional, and random disturbances." Ashby states the "first effect" of a house is "to keep the air in which [one] lives at a more equable temperature," and mentions the role of roofs, the opening and closing of windows, and stoves to this effect. [19]

On another level, while Ashby selects from a random number table together with feedback to return the homeostat to equilibrium in light of drastic environmental changes, Alexander uses

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[16] Philip Steadman also explicates the parallel between Alexander and Ashby. See Philip Steadman, *The Evolution of Designs : Biological Analogy in Architecture and the Applied Arts* (New York: Cambridge University Press, 1979), Chapter 12.
[17] Alexander, *Notes*, 49.
[18] Ibid., 102.
[19] Ashby, *Design*, 62.

potentially random form-type selections mediated by feedback in the form of cultural traditions. The form maker in Alexander's "unselfconscious" design cultures can respond to a larger environmental disturbance, for example, by building a new house. This is to be achieved by the form maker selecting a copy of an existing building typology or form-type. However, while the selected variations in the copy can be random, according to Alexander they will not be radically divergent from existing forms. This is because the form maker is said to respond promptly to design irregularities, such as a culturally non-traditional built form: "The direct response is the feedback of the process" and "control [of design typology] is provided by the resistance to change the unselfconscious culture has built into its traditions."[20] The feedback process is said to be "damped" by design tradition.[21] The negative feedback loop that functions to regulate the homeostat's internal environment in light of external environmental variations is applied to the process of designing by substituting type-forms for electricity. That is, whereas in Ashby electrical currents are damped through negative feedback, in Alexander building typologies are controlled through negative feedback. Thus on two levels Alexander's design process mimics the functional behaviors of the homeostat.

Furthermore, essential to the stability of the Homeostat is the idea of a subsystem that must be able to adapt separately from other subsystems (see Figure 3.5). As Ashby phrased it:

> What I am suggesting is that there is a form intermediate between the environment in which everything upsets everything else and the environment which is cut into parts. This intermediate type of environment is common and is of real significance here; it is an environment that consists of parts that are temporarily separable, and yet by no means permanently separable. For instance, at the moment, the properties of this piece of chalk I am holding go on, as far as its writing power is concerned, more or less independently of what the eraser is doing; they are to some extent

[20] Alexander, *Notes*, 51.
[21] Ibid.

independent. If I move the chalk, the eraser does not immediately burst into flame. If it did and I had to deal with an environment of that crazy type, the whole business of getting control of what was going on around me would be much more difficult. Fortunately, the environment is not always as complicated as that, and I think it is that simplicity which enables the living organism to take on peculiarities and get control over them.[22]

For Ashby, a system's variables must form subsystems of linkages which are not connected to all other variables. Subsystems of these "ultrastable" variables are said to be arranged within the larger overall system of organism and environment: Ashby writes: "*within a multistable system, subsystem adapts to subsystem in exactly the same way as animal adapts to environment* [emphasis original]."[23] Ashby's subsystems permit the overall system to produce complex behaviors, rather than the simple chaining behaviors of the stimulus-response models then popular amongst American behaviorist psychologists.[24] Ashby believed that with this arrangement of ultrastable subsystems he had discovered in the homeostat the principle responsible for homeostatic behaviors in organism or machine.[25] Thus it is not a question of whether nature is a metaphor for the machine of the machine a metaphor for nature; it is a question of what conditions the possibility of either machine or nature to

[22] Ashby, "Homeostasis," 82-3.

[23] Ashby, *Design*, 174.

[24] However, Ashby's formulation does not approach the complexity of Donald O. Hebb's 1949 landmark neurophysiologic study *The Organization of Behavior*, which sought to explain global brain states hierarchically in terms of highly local neuronal events; D. O. Hebb, *The Organization of Behavior: A Neuropsychological Theory* (New York: Wiley, 1949), 335; John M. O' Donnell, *The Origins of Behaviorism: American Psychology, 1870-1920*, (New York: New York University Press, 1985).

[25] Attempts to apply the principle of natural selection, or learning as adaptation, has a long history in behaviorist psychology and stimulus-response models, which studied how animals learn behaviors as a result of conditioning processes. For example, Ivan Pavlov developed a model for conditional reflexes, B.F. Skinner advanced reinforcement conditioned stimulus-response arcs, and Clark Hull attempted to show that human learning was a mechanical operation of adaptation developed through associations of stimulus and a resulting generalization. Ivan Pavlov, *Conditioned reflexes*, trans. and ed. G.V. Anrep, (New York, Dover Publications, 1960); John O' Donnell, *The Origins of Behaviorism: American Psychology, 1870-1920* (New York: New York University Press, 1985).; B. F. Skinner, "The Concept of the Reflex in the Description of Behavior," *Journal of General Psychology* 5 (1931): 427-458; Edwin Garrigues Boring, *A History of Experimental Psychology*, 2d ed. (New York: Appleton-Century-Crofts, 1950), 777.; Clark Leonard Hull, *Principles of Behavior: an Introduction to Behavior Theory* (New York: D. Appleton-Century Company, Incorporated, 1943), 422.

behave homeostatically. Ashby answers this question through simulation, by assigning responsibility to his "ultrastable" variables.

Correspondingly, Alexander advanced the idea that a successful method of design is a form of homeostatic adaptation which must proceed through a series of independent subsystems, each generating adaptive behaviors:

> We may ... picture the process of form-making as the action of a series of subsystems, all interlinked, yet sufficiently free of one another to adjust independently in a feasible amount of time. It works, because the cycles of correction and recorrection, which occur during adaptation, are restricted to one subsystem at a time.[26]

Ashby envisioned complex adaptive behavior contingent upon independent subsystems, each subsystem able to adapt independently for accumulation of adaptive behaviors. Alexander translated the principle which made possible the ultrastability of the Homeostat to explain the design method of "unselfconscious" cultures. "Unselfconscious" design is explained by a machine simulating what conditions the possibility of adaptation in nature.

Yet what of these "unselfconscious" design cultures? Alexander offers an "'ideal' primitive society as a mental construct which serves a useful basis for comparison."[27] Such "cultures [serve] to contrast ...with others, including our own."[28] This idealization is a leveraging of the work of American anthropologist Robert Redfield. In 1947 Redfield offered the proposal of "The Folk Society:"

> The ideal folk society could be defined through assembling, in the imagination, the characters which are logically opposite those which are to be found in the modern city...we move from folk society to folk society, asking ourselves what it is about them that makes them like each other and different from the modern city. So we assemble the elements of an ideal type.[29]

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[26] Alexander, *Notes*, 43.
[27] Ibid., 199n10.
[28] Ibid., 32.
[29] Robert Redfield, "The Folk Society," *The American Journal of Sociology* 52, no. 4 (1947): 294.

The folk point of view generates historical and ethnographic fables, deprives "folk" of agency, and invents culture. This view of culture defines unity and demarcates the boundaries of people whose integrity is politically equivocal.[30] Specific rituals are dissolved, social cleavages on which history turns are effaced. This loses both empirical specificity and imparts "our" rationality through the "logical" construction of folk societies which continues the Western positivist tradition of contrasting metaphor and reality.[31] Universal reason, "logic" is opposed to particular cultural constructions and permits their erasure.

In Alexander, the rationality of a Western machine invention replaces the "folk" views of things, leaving a fictional history. His appeal to a machinic simulation of homeostasis turns the specificities of non-Western rationalities into a machine, for a machine which transforms information is to explain the design method of "unselfconscious" cultures. In these cultures, storage exists in the designed objects. The maker is merely an "agent" of design selection.[32] The designer facilitates selection with feedback processing through cultural norms damping the dangerous oscillations that could derail homeostasis. Each of selection, storage and processing is a separable function. Design forms are created through selection, including errors, and their correction through an externalized, cultural process of controlled feedback. Not only does Alexander apply the functioning of a machine that is to simulate the principle which makes possible homeostasis to explain the method of designing in pre-modern cultures. Furthermore, this machine is more generally a machine which transforms information. This is significant because in enlisting a machine

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[30] Elias, Norbert, *The Civilizing Process: the History of Manners,* (New York: Urizen Books, 1978), 5-6.
[31] Marshall Sahlins, *How "Natives" Think: About Captain Cook, For Example* (Chicago: University of Chicago, 1995), 197-8.
[32] Alexander, *Notes*, 52, 77.

that transforms information Alexander equates its operations with norms of designing. Technological regulation replaces pedagogic normativity.

Misfit

Ashby's focus is the homeostatic interrelations of organism and environment. Alexander's is the homeostatic interrelations of form and context - for design, Alexander advances, concerns itself with securing a "fit" between form and context. Take an example Alexander gives, that a piece of metal must fit flush against another piece.[33] The form is the piece of metal. The context is the already existing piece. Fitness in this instance is flatness. What is "required" of milling a piece of metal is that it must be flat.[34] A misfit would then be a bump on the metal's surface. When a misfit exists a requirement is not met. However, the term "fit" - "the absence of misfits "[35]- is a problematic concept of Alexander's because only by defining misfit can what is fit be identified. What one experiences is a lack of fit, which Alexander poses as deviation from a norm.

A norm can serve as a rule of conduct, a principle of conformity. As such, a norm is opposed to irregularity, unevenness, deviation and strangeness. For Alexander, following norms is to correct misfit by intercession and modification:

> Our own lives, where the distinction between good and bad fit is a normal part of everyday social behavior...If a man wears eighteenth-century dress today, or wears his hair down to his shoulders, or builds Gothic mansions, we very likely call his behavior odd; it does not fit our time. These are abnormalities. Yet it is such departures from the norm which stand out in our minds, rather than the norm itself. Their wrongness is somehow more immediate than the rightness of less peculiar behavior, and therefore more compelling.[36]

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[33] Ibid., 19-20.
[34] Ibid., 20.
[35] Ibid., 27.
[36] Alexander, *Notes*, 22.

By moving from a physical question of whether two pieces of metal are flush to cultural normativity, Alexander elides distinctions between a material concern of being adapted to prevailing conditions and a cultural construction of abnormality. This conceptualization of normal is a norm which imposes requirement on existence. The normative joins a principle of qualification and correction, an attitude of intervention and alteration.[37] Persons, and society, are thought to equilibrate around an assumed norm and any deviation from this standard is considered indicative of strangeness.

However, a norm can also serve as a functional regularity, as the principle of an appropriate and well adapted biological functioning. In this sense the normal is opposed to the pathological, disorganized and dysfunctional. Ashby employs a sense of normal that is intermediary between a meaning opposed to irregularity and a meaning opposed to dysfunction. For example, Ashby states that the homeostat shifts from "appropriate" to "inappropriate" behaviors.[38] It does so by "the very fact that it goes outside the normal limits."[39] Here normativity is applied to a machine that deviates from norms of functional regularity. However, the machine is also said to receive a "punishment" when it moves outside this range of "normal" behaviors.[40] Outside these "normal" states the homeostat behaves improperly, for which it receives reprimand. In this sense cultural normativity is applied to a machine that deviates from the normal, from "its central optimal position,"[41] as from norms of conduct.

Later in *Notes*, each of health, normality and well-fitting forms are all presented as issues of appropriate adaptation drawn from a biological model of fitness: "Both the concept of organic health

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[37] For Michel Foucault's interpretation of Canguilhem's conceptualization of norm, see Michel Foucault, *Abnormal: Lectures at the Collège de France 1974-1975* (London: Verso, 2003). My interpretation draws on Focault's.

[38] Ashby, "Homeostasis," 76.

[39] Ibid., 93.

[40] Ibid., 104.

[41] Ibid., 98.

in medicine and the concept of psychological normality in psychiatry are subject to the same kind of difficulties as my conception of a well-fitting form or coherent ensemble."[42] Yet what is misfit in Alexander's definition can be functionally adaptive. Alexander's reference to the equivalence he postulates between health, normality and well-fitting forms is from the psychiatrist Geoffrey Vickers. Vickers writes "what we call disorganization may be, perhaps always is, a form of defensive reorganization."[43] Passed a threshold internal coherence is lost or only supported by a neurosis - which is adaptive. Adaptation can no longer be taken as an analogue for "fit". Instead, misfit founds fit, can only be defined through misfit. Misfit makes the metaphor of fit possible.

Note that in 1952, the year *Design* was published, Ashby presented at the Macy Conferences. The Macy Conferences were a seminal series of meeting sponsored by the Josiah Macy Foundation that occurred in New York City between 1946 and 1956. These conferences drew together luminaries of the natural and social sciences: in addition to attendees such as mathematicians John von Neumann and Norbert Wiener, the conferences included, for example, psychologists Lawrence Kubie and Wolfgang Kohler, anthropologists Margaret Mead and Gregory Bateson and sociologist Talcott Parsons. Although the Macy Conferences have been well covered, it has been less noted that psychological pathologies were a recurrent theme addressed at these meetings.[44] In particular neurosis was much discussed.[45]

The psychologist Lawrence Kubie was the first to propose a theory of neurosis which considers it a result of an arrangement of neuron pathways such that impulses are re-circulated to

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[42] Alexander, *Notes*, 198n21.
[43] Sir Geoffrey Vickers, "The Concept of Stress in Relation to the Disorganization of Human Behavior," in *Stress and Psychiatric Disorder*, ed. J. M. Tanner (Oxford: Blackwell Scientific Publications, 1960), 3.
[44] See N. Katherine Hayles, *How We Became Posthuman*; Jean-Pierre Dupuy, *The Mechanization of the Mind: On the Origins of Cognitive Science* (Princeton: Princeton University Press, 2000).
[45] For a discussion of neurosis at Macy see also N. Katherine Hayles, "Boundary Disputes: Homeostasis, Reflexivity, and the Foundations of Cybernetics," *Configurations* 2, no. 3 (1994): 441-467.

cause positive feedback or reverberation. Kubie remarked that "the principle of reverberating circuits and of feedback relationships comes to mind repeatedly in connection with the clinical problem of neurotic patients."[46] The neurologist Warren McCulloch often posed neurosis in terms of disorders of informational organization.[47] Wiener stated that entropy "is closest [in its concept] to psychology," and translates to the physical and biological by the common factor of information.[48]

These stances articulated at the Macy Conferences employ a particular understanding of information. Drawing on advances in the statistics and thermodynamics, engineer Claude Shannon and statesman of science Warren Weaver's offered their massively influential 1949 *Mathematical Theory of Communication.*[49] In this text information was synonymous with negative entropy or the measure of the order of a system. Wiener also postulated this equivalence in his 1948 *Cybernetics: or, Control and Communication in the Animal and the Machine* and again in his popular 1950 text *The Human Use of Human Beings.*[50] At Macy, modeling neurosis as a disorder of information meant it could be modeled in humans or machines through the common medium of a locked feedback loop. Thus distinctions between humans and machines were blurred when explaining dysfunction as well as homeostatic regularity.

Likewise, in a 1961 paper, Alexander posed design ability as the capacity to order matter. He viewed this as a child's source of creativity.[51]

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[46] Lawrence Kubie, in *Cybernetics*, vol. 6, 74.
[47] Warren McCulloch, in Ibid., 97,99,111.
[48] Norbert Wiener, in Ibid., 106.
[49] Claude Elwood Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).
[50] Norbert Wiener, *Cybernetics; or, Control and Communication in the Animal and the Machine* (Cambridge, MA: Technology Press, 1948); Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (Boston: Houghton Mifflin, 1950).
[51] Christopher Alexander, "The Origin of Creative Power in Children," *British Journal of Aesthetics* 2, no. 3 (July 1962, 1962): 207-226.

> The source of creative talent can be fully understood in terms of the child's developing ability to force the forms apart from one another....It is one of the central results of statistical thermodynamics and information theory that this kind of uniqueness or low entropy is the same as what we usually call order.[52]

Additionally, he posed human psychology could be understood as problems surrounding the processing of information, that stating in *Notes* when discussing the use of concepts: "Any psychological inquiry which treats perception or cognition as information processing is bound to come to the same kind of conclusion."[53]

Moreover, "selfconscious" or then-contemporary design cultures are referred to by Alexander as "pathological."[54] "Anxious," the individual form maker in "selfconscious" design cultures suffers a neurosis due to a reliance on intuition.[55]

> The moment [the designer] becomes aware of his own weakness [due to a reliance on intuition] in the face of the enormous challenge of a new design problem, he takes steps to overcome his weakness [which relies on intuition]; and strangely enough these steps themselves exert a very positive bad influence on the way he develops forms.[56]

Anxiety causes a flailing resort to intuition. However it was this initial reliance on intuition that brought on the form maker's anxiety. "Selfconscious" design is thus conceived as neurotic feedback loop, a mechanism applicable to animate or inanimate machinery.

Alexander indeed marshals Sigmund Freud:

> In denying the possibility of understanding reasonably the processes of form production [in modern design culture], the fetish of intuition is closely parallel to other famous attempts to shelter from the loss of innocence under the wings of magic and taboo; see, for comments, Sigmund Freud, *Civilization and Its Discontents*.[57]

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52 Ibid., 224-225.
53 Alexander, *Notes*, 198n20.
54 Ibid., 56.
55 Ibid., 57.
56 Ibid., 59-60.
57 Ibid., 195n17.

The fetish is a kind of creative denial that assists the fetishist in displacing anxiety while producing a kind of amnesia, much as the Homeostat functioning of the "unselfconscious" socio-cultures displaces disequilibrium through selecting its one-second memory. This memory the biologist Henrich Klüver relates the machine to the story of a man who could not remember anything for longer than one second:

> Although there was complete loss of memory in that every sight, sound, taste, smell, touch and pain was completely forgotten after one second, there was no disturbance in other psychological functions, but there was even no memory for emotional experiences beyond the time period of one second. It looks, therefore, as though Dr. Ashby's machine behaves somewhat like [a] gas-poisoned patient.[58]

The machine selects information from the environment (the random table of numbers) which is then processed, but fails to retain this information. Klüver concluded that Ashby's machine may be "of some help in understanding pathology of [psychological] behavior."[59]

As theorist Homi Bhabba writes:

> The scene of fetishism functions…as, at once, a reactivation of the material of original fantasy - the anxiety of castration and sexual difference - as well as a normalization of that difference and disturbance.[60]

At Macy, Wiener tried to naturalize the norms of psychological pathology:

> There is something always in the unconscious that deals with a process by an affective coloring. This affective coloring is the raw material out of which norms are made, so it isn't a pathology. It isn't a normal pathology but a pathology of norms that we are interested in in this situation.[61]

Naturalizing norms by locating their cause could permit psychology to be treated as natural science and hence treatable by mathematical communication theory. Naturalizing norms of functional

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[58] Henrich Klüver, in *Cybernetics*, vol. 9, 107.
[59] Ibid.
[60] Homi K. Bhaba, "The Other Question: Stereotype, Discrimination and the Discourse of Colonialism," in *The Location of Culture* (London: Routledge, 1994), 74.
[61] Wiener, in *Cybernetics*, vol. 6, 86.

regulation would permit a natural science justification of abnormalities in terms of disorders of information.

In Alexander's "selfconscious" design cultures, storage exists in design drawings and the minds of individual designers. The designer is no longer merely an "agent" of design selection with the storage in the designed objects and the cultural environment responsible for the damping of a design feedback process. Rather, the designer must select, process, and store design information internally rather than through an external functional separation. Alexander writes:

> [In selfconscious design cultures] form is shaped not by interaction between the actual context's demands and the actual inadequacies of the form, but by a conceptual interaction between the conceptual picture of the context which the designer has learned and invented, on the one hand, and ideas and diagrams and drawings which stand for forms, on the other. This interaction contains both the probing in which the designer searches the problem for its major "issues," and the development of forms which satisfy them; but its exact nature is unclear. In present design practice, this critical step, during which the problem is prepared and translated into design, always depends on some kind of intuition.[62]

These technologies of selection, storage and processing are not functionally delineated in Alexander's version of then-contemporary design cultures. Rather, they are bonded through the use of intuition. This means storage and selection without a separate and controlled feedback process leads to undamped oscillations without reaching homeostasis.

In this, both technology and human behavior are given in terms of their use value, in instrumentally rational terms, in which the most efficient functional means is sought for a given end. The end is given as equally fitness between form and context or adaptability between organism and environment. This is a particularly conservative view of behavior. This blurring between the human and inhuman in normative situations hinges upon the means-ends utility of an information machine.

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[62] Ibid., 77.

"Abnormal" situations are when the process of design does not operate as an instrumental information machine. In this case designs are said to fail and designers exhibit psychological pathologies. Designer's pathologies are considered in the same terms as machine pathologies, delineated by formations of neurotic feedback loops, but such malfunction means the use value of the designing-machine fails. The technologies of information storage, selection, and processing are not separate in "selfconscious" design cultures, but this is the reason why design does not work, it loses its utility, as an information machine. In other words, when the process of design fails to adhere to this particular way of dividing the world, as information and into its separable selection, storage, transmission and processing, the designer is disorganized. This disorder is not only allied with mental disorganization but is reinforced as a negative or undesirable thing because it is not purposeful.

Harvard Center for Cognitive Studies

In addition to his PhD work, Alexander was involved in conducting psychological experiments as a Research Fellow at the CCS. In the "General Description" of the CCS, written by co-founders psychologists Jerome Bruner and George Miller for a National Science Foundation (NSF) grant application, cognitive psychology was to embrace human thinking processes and information devices alike. It was to "have application not only to the study of man but also to the devices man uses to amplify his cognitive control over the environment."[63] Between 1960 and 1966, the CCS obtained more than $2 million in grant money from among supports such as the NSF, Ford Foundation, and the Advanced Research Projects Agency of the Department of Defense.

[63] George Miller and Jerome Bruner, "Application for Grant, Harvard Center for Cognitive Studies: General Description," April 8, 1960, 1, Box 1, Papers of Jerome Bruner, National Science Foundation, 1959-1961 (HUG 4242.9), Harvard University Archives

In November 1960, the fall of the founding of the CCS, Bruner wrote an earnest letter to Harvard Dean McGeorge Bundy, appealing the presence of polymath economist, administrative theorist, founder of artificial intelligence and budding cognitive psychologist Herbert Simon:

> It seems to me that Simon's presence here would almost automatically facilitate some of the kinds of development that we have been talking about for several years now. For one thing, the enterprise which, for lack of a better name, I call "automatic information processing" is right down the Simon alley. So too the problem of programmed instruction ...in the sense of what constitutes optimum sequencing of information. Simon has also proven interest in various kinds of machine simulation....
>
> Why now? Well, the first and obvious answer is that we need him now more than ever before...[64]

In turn, in 1953, Simon wrote to Ashby. He offered that Ashby's book *Design* was "the most exciting book I have read in a decade."[65] Additionally, the historian Jean-Pierre Dupuy recounts speaking with Simon at a colloquium in his honor: "I asked the founder of artificial intelligence what influence cybernetics had had on him. 'The only cybernetician who has had any impact on my work,' he replied, 'is Ross Ashby.'"[66]

In a letter of response, Ashby wrote

> It is my firm belief that the principles of 'organisation' are fundamentally the same, whether the organization be of nerve cells in a brain, of persons in a society, of parts in a machine, or of workers in a factory....I have long been of the opinion that the problem of how ten billion nerve cells work harmoniously together in a brain is the same problem of how two billion people can work harmoniously together in a society.[67]

It is in *Design*, Ashby concludes the letter, which elucidates how such organizations are created.

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[64] Letter from Jerome Bruner to McGeorge Bundy, November 4, 1960, Box 3, Papers of Jerome Bruner, Correspondence, 1961-1962 (HUG 4242.5), Harvard University Archives.

[65] Letter from Herbert Simon to Ross Ashby, June 15, 1953, quoted in Hunter Crowther-Heyck, *Herbert A. Simon : The Bounds of Reason in Modern America* (Baltimore: Johns Hopkins University Press, 2005), 189.

[66] Jean-Pierre Dupuy, *The Mechanization of the Mind*, 188n9.

[67] Letter from Ross Ashby to Herbert Simon, July 23, 53. Quoted in Crowther-Heyck, *Herbert A. Simon : The Bounds of Reason in Modern America*, 190.

In the early 1960s Simon proposed that the evolution of complex systems relies upon a separable collection of subsystems. The subsystems are a series of "stable configurations."[68] Like in Ashby, their stability depends upon their level of interaction with other stable configurations. If there is excessive interaction between configurations, change in one would affect too much other subsystems and the evolution of complexity that, according to Simon, we see in the environment could not have been achieved in the amount of time available: "the expected time required for the system to reach a particular state is inversely proportional to the probability of the state - hence increases exponentially with the amount of information (negentropy) of the state."[69] In short, storage is in the stable subassemblies and processing occurs between them in the form of information interactions. This evolution of complexity Simon applies to biology, social networks, the structure of diamonds and human problem solving. Each was seen as an information machine, with separable storage and processing.

Not only did Alexander mobilize Simon several times in *Notes*, but in a paper Alexander wrote while holding his fellowship at the CCS, he proposes to explain the ideal process of design as a method of "information storage and retrieval."[70] "The whole process of [information storage and retrieval] is, in a way, the same as the problem of building up a process of design."[71] Alexander seeks an isomorphism between an externalizable process of design as information storage and retrieval and the internal processes of memory and selection of design information. In turn, this external process of storage and retrieval "really needs to reach the same order as the neurological communication

[68] Herbert Simon, "The Architecture of Complexity," *Proceedings of the American Philosophical Society* 106, no. 6. (1962): 473.
[69] Ibid., 470.
[70] Christopher Alexander, "Information and an Organized Process of Design," *New Building Research, Building Research Institute* (1961): 115. Simon is cited in Alexander, *Notes*, 206n1, 208n15, 211n5.
[71] Ibid., 116.

which takes place within an individual designer's brain."[72] When a design is less than ideal it is a failure of storage and selection: "If a design process is to make optimum use of the information available, it must be possible to set up temporary isomorphisms between [information storage and retrieval] and the cognitive organization of the process."[73] In the ability to create an isomorphism between the neurology of the brain and information storage and selection, the mind becomes an information machine and the information machine a living brain.

The web of connections grows thicker. In 1958, sponsored by the Ford Foundation and the Social Science Research Council, Simon and Miller together with computer scientist and cognitive psychologist Alan Newell organized a summer seminar at the RAND Corporation to introduce simulation efforts to the investigation of human problem solving.[74] In the fall of 1956, Miller had arrived for a year's stay at Stanford's Center for Advanced Study in the Behavioral Sciences with a stack of yet unpublished documents by Newell, Simon, and the pioneering programmer J.C. Shaw.[75] During his stay Miller discussed this material with two other fellows: Eugene Galanter, another psychologist, and Karl Pribram, a neurophysiologist with interests in psychology who had been a visiting lecturer at Harvard and MIT in the mid 1950s.[76] These discussions contributed to the 1960 book *Plans and the Structure of Behavior* (hereafter *Plans*), and Miller's research towards this effort

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[72] Ibid., 115.
[73] Ibid., 120.
[74] David A. Hounshell, "The Cold War, RAND, and the Generation of Knowledge," *Historical Studies in the Physical and Biological Sciences* 27, no. 2 (1997): 261; Allen Newell and Herbert Simon, *Human Problem-Solving* (Princeton: Prentice-Hall, 1972), 886; Herbert A. Simon *Models of My Life* (New York: Basic Books,1991), 222-224, 245.
[75] Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1996): 221.
[76] Ibid., 230.

would also serve as a vital aspect in Miller's co-founding with Bruner of the CCS in 1960.[77] Alexander also leverages *Plans* in various publications during the early 1960s.[78]

The TOTE unit, an acronym for "test-operate-test-exit," held *Plan*'s theoretical concept (see Figure 3.6). A system (computer, mechanical, or human) consisted of a hierarchy of TOTE units which comprised a Plan. A system selected an operation to be performed, tested the operation's results against a goal state, and continued this feedback process until the goal was attained, at which point the Plan transmitted control to the next level in a hierarchy of sub-plans.[79] In *Plans* the authors use the practice of list structures for representation pioneered by Simon, Newell, and Shaw to signify the organization of thought: the "structure underlying behavior is taken into account in a way that can be simply described with the computer language developed by Newell, Shaw, and Simon for processing lists."[80] *Plans* treats behavior as the execution of a program, the authors noting "we are reasonably confident that "program" could be substituted everywhere for "Plan" in the following pages."[81] In a Plan comprised of TOTEs, after a goal is stored, an operation is selected, processed by feedback, with transmission between sub-plans.

Plan's authors also posited the brain as operating in terms of selection, transmission, storage, and processing:

> One notion, for example, is that the cerebral cortex provides the memory unit, that the limbic areas somewhere house the processing unit, and that the cerebellum is a digital-to-analogue converter in the output system. The primary projection areas

[77] George A. Miller, Eugene Galanter, and Karl H. Pribram, *Plans and the Structure of Behavior*, (New York: Holt, Rinehart, and Winston, 1960).
[78] *Plans* is cited in Christopher Alexander, "Information and an Organized Process of Design," *New Building Research, Building Research Institute* (1961): 115, and in Alexander, *Notes*, pp. 196n15, 208n14.
[79] It is the same principle of feedback central to the seminal piece by Arturo Rosenblueth, Norbert Wiener, and Julian Bigelow, "Behavior, Purpose and Teleology," *Philosophy of Science* 10 (1943): 18-24. See Miller, Galanter, and Primbam, *Plans*,.23; Paul N. Edwards, *The Closed World*, 230.
[80] George A. Miller, Eugene Galanter, and Karl H. Pribram, *Plans and the Structure of Behavior*. 16.
[81] Ibid.

> could provide short-term storage for images that would be operated upon by programs stored in the adjacent association areas.[82]

Moreover, neurological disorders are framed in terms of failures of a computer's processing unit. The TOTE can fail to perform in two conditions. One, a TOTE can get "jammed" in the test phase, "so that the test always passes or always fails."[83] Two, a TOTE can become disordered. Miller et al give the following example:

> A ... kind of symptom appears as damage to the hierarchical relation between TOTE units....What happens when the hierarchical structure of TOTEs is disrupted is nicely illustrated by the behavior of a mother rat with limbic lesions. When a normal mother rat is faced with a situation in which her brood has been strewn around the cage, she will pick up one baby rat and carry it to the nest, go back to pick up another and return it to the nest, etc., until all the youngsters are safely back in the nest. This behavior does not appear when the mother has had a surgical operation to remove the cingulate cortex .... The surgically operated mother will pick up an infant, carry it part way to the nest, drop it in favor of another which may be carried to the nest only to be removed on subsequent trips. After half an hour of this the baby rats are still strewn all over the nest and, eventually, are left to die.[84]

The use value regulations of an information machine are to explain norms of biological functioning. Abnormal behavior is non-instrumental and hence non-rational behavior. Such behavior is considered in terms of a disorganized method of information processing.

Alexander's Program

The final sections of *Notes* provide Alexander's solution to the pathologies of "selfconscious" design cultures with his new design method. This is contingent upon a new architectural program. Note that in 1958, architectural historian John Summerson defined an architectural program as "a description of the spatial dimensions, spatial relationships, and other physical conditions required for

[82] Ibid., 199.
[83] Ibid., 205.
[84] Ibid., 207.

the convenient performance of specific functions."[85] In this program he saw the distinguishing characteristic of modernist architecture. Particularly, he viewed the "program as a source of unity."[86] The conception of this unity relied upon biological analogies, citing Lászlό Maholy-Nagy on the matter, that "architecture will be brought to the fullest realization only when the deepest knowledge of human life as a total phenomenon in the biological whole is available."[87] Both Alexander and Summerson compare architecture and biology. However, Alexander's analogies are not exclusively biological. They apply equally organism or machine. Moreover, sentient and technological are unified through the common medium of information. It is no longer a question of whether the machine is a metaphor for nature or whether nature underlies the machine. Rather, information is to condition the possibility of both. Alexander's program further differs from Summerson's because Alexander proposes an architectural program as a sequence of operations an architect or computer can perform automatically. In an architectural program that is equally a computer program, Alexander locates in information-based simulation what provides the possibility for design.

To remedy what he saw as the pathological failures of then-contemporary design cultures, Alexander wrote several computer programs in assembly code that he grouped under the term HIDECS (Hierarchical DEComposition of Systems) (see Figure 3.7). These programs were similar to the programs of Miller et al and Simon because the simulation of thought works like a machine that transforms information. Multiple sub-routines served as feedback processes within a hierarchy of sub-routine levels. At each level, when, after a selection of error-reducing actions the present state tested equal with a goal state, these were stored and control transmitted to a next level sub-routine.

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[85] John Summerson, "The Case for a Theory of Modern Architecture," reprinted in *Architecture Culture: 1943-1968, A Documentary Anthology*, ed. Joan Ockman (New York: Columbia Books of Architecture/ Rizzoli, 1996), 233.
[86] Ibid.
[87] Ibid, 231

This continued until the final goal state was met (see Figure 3.8). The "unselfconscious" design culture, a design culture that for Alexander functioned as a machine that transforms information, could now be simulated on a digital computer. Alexander imparts appropriate technological regulation to respond to the failures of "selfconscious" design through intervention and correction towards machine-based normalization (see Figure 3.9).

Specifically, to examine what Alexander's computer programs did, take an example he uses. Consider that the design task is to make a tea kettle (see Figure 3.10). This is comprised of requirements, or "the individual conditions which must be met at the form-context boundary, in order to prevent misfit."[88] One requirement might be "must heat as rapidly as possible." Call this m_1. Another requirement might be "must be as light as possible." Call this m_2. L is a set of the interactions between these requirements. L is a set of links, each link joining two elements in M. A link is coded 1 if two elements interact and 0 if they can coexist.[89] In this example m_1 and m_2 interact. Therefore l_1, the link between m_1 and m_2, would be coded 1. The two sets M and L define a linear graph, a network, G(M,L), in which the elements in M are nodes and the elements in L are links between nodes. However, since Alexander requires that there is only one link between each set of requirements, L serves to fully define G. The requirements for the design project are then entirely captured as sets of links coded 0 and 1.

Alexander then defines a mathematical measure of "informational transfer," based upon Claude Shannon's information theory (see Figure 3.11). This measure is applied to G to generate a decomposition of subsets which minimize the amount of information transfer between sets.[90] This is important for the program because it permits the sets to be treated independently. Alexander uses

[88] Alexander, *Notes*, 80.
[89] Ibid.
[90] Ibid., 125.

this measure to generate the most informationally independent subsets of G: G is decomposed into the most informationally independent subsets $g_1,...g_n$ by using iterations to select each partition of the subset located up to that point with the least information transfer.

On one level, the binary encoding of requirements is the analog storage device of "unselfconscious" design information in 0's and 1's. Each subset of least interaction or least "information transfer" is a storage unit. Data transmission occurs in the lines of network between these sub-system specifications. On another level, storage exists in the memory of the IBM 704, 709, and 7090 which Alexander employed at the MIT Computation Center (see Figure 3.12, 3.13].[91] Information transmission exists in the data channels connecting the card punch to the multiplexor. Processing in the CPU was enabled by the computer programs HIDECS Alexander wrote to perform the process of selection to store the specification of requirements and transmission between subsets of selected requirements.[92] This dual layering of instrumental information machines is significant because only when the use value of an information machine returns can design function properly for Alexander. The non-useful is allied with the psychologically pathological.

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[91] These computers were made available through a combination of IBM donation, NSF, Air Force and Navy financing. The demand to use these digital computers was steep. Amongst approximately 100 other Ph.D. students annually in the early 1960s, professors, labs, and IBM itself vied for time on these computers. Karl Wildes and Nilo Lindgren, *A Century of Electrical Engineering and Computer Science at MIT, 1882-1982* (Cambridge, Mass.: MIT Press, 1985), 423; Division of Sponsored Research. Massachusetts Institute of Technology. *Financial Report* (Cambridge, MA: The Division,1958-1967).

[92] These techniques are described in Alexander, *Notes*, Appendix; Christopher Alexander, *HIDECS : Four Computer Programs for the Hierarchical Decomposition of Systems which have an Associated Linear Graph* (Cambridge, MA: MIT, 1963).; Christopher Alexander and Marvin L. Manheim, *HIDECS 2: A Computer Program for the Hierarchical Decomposition of a Set which has an Associated Linear Graph* (Cambridge, MA: Dept. of Civil Engineering, Massachusetts Institute of Technology, 1962). Assembly code is essentially machine code, only simpler for humans to program due to the use of mnemonic tags to machine language, rather than having to program in binary code itself. Assembly code is hardware specific, and so programming depends a great deal on accommodating the architecture of the machine itself.

The structure of unselfconscious design is represented by a machine that transforms information through feedback - by a cybernetic designing machine.[93] If there is an analogy between cybernetic design and the operations of cultural consciousness, it is because cultural design consciousness is already inhabited and made possible by a machine, the cybernetic design machine. For Alexander, the cybernetic design machine has its origin in the cultural unselfconscious. Unselfconscious processes cannot be conceived apart from or exterior to a cybernetic design machine. The cybernetic machine founds design and thus makes its metaphor possible. The invention of a new machine - a computer - reveals further how the norms of cultural design were already provided by a machine.

Conclusion

In response to Alexander's dissertation, Jerome Bruner summarizes to the architect Norman Newton his impressions:

> The kinds of mathematics he proposes are most useful when one is working with well-defined problems where there is a clear criterion for determining whether one or another of the two values of a binary state are present -- i.e., that a given design feature is present or absent. If there is a clear cultural criterion of whether some particular feature of design is a "fit" or a "misfit," then he has an interesting way of proceeding...If not, or if there are so many features to be taken into account whose relative values are unclear, then I think that the concluding chapters could be considered an example of premature formalism. I cannot judge whether his formalization does in fact precede our proper understanding of the process of design. My principal feeling is that it would be interesting to see whether Mr. Alexander can apply his rather abstract apparatus to a concrete example of architectural design -- not to solve the problem of the design, but simply to represent the process.[94]

[93] The structure of this argument is taken from Jacques Derrida,"Freud and the Scene of Writing" in *Writing and Difference*, trans. Alan Bass (Chicago: University of Chicago Press, 1978).
[94] Letter from Jerome Bruner to Norman T.Newton, December 29, 1960, 2, Box 1, Papers of Jerome Bruner, Correspondence, 1961-1962, (HUG 4242.5), Harvard University Archives

The problem of design Alexander wished to solve involved minimizing as much as possible the use of intuition. Intuition is a facet of irrationality for which its absence is exemplified in terms provided by an information machine. When such a machine fails, however, distinctions between human and nonhuman remain. An erasure of difference between people and machines is not lost. Rather, this blurring continues when these information machines lose their utility and fall into dysfunction. In this disordered situation, humans are configured as faulty information machines, intuition as though a machine "bug" (again the term referring to sickness, as in catching a cold) causing neurosis - a neurosis of feedback loops that can be manifest by machine. Humans become malfunctioning machines and technology displays mental pathologies.

The separation of information selection, storage, transmission, and processing in an appropriately functioning information-machine-designer is significant because it cuts up designing in a particular way as separable chunks of data. Instrumental design is then associated with the ability to divide the world into bits of information according to these compartments. Since these separations, when they fail, no longer support a functionally instrumental information-machine-designer and rather cause the designer to display neurosis, these separations enforce the prevailing view of neurosis as dysfunctional. Adaptation and norms, cultural and technical, are then called upon to correct the ailing information machine that is the designer. These norms are to return the designer to his or her proper instrumental functioning as always having been a pathology-free machine that transforms information, that is purposeful in terms of use value of an information transforming machine.

In concluding to Norman, citing his lack of experience with design theory, Bruner speculates:

You will have to judge whether his pioneering attempt into new ways of considering the elements of design is a genuine contribution to the theory of design, or whether it is so formalized as to be something of a "crank" performance.[95]

[95] Ibid.

Chapter 4 - Design Methods, Ergonomics and Information, 1944-1962

Writing as a leading figure of architectural modernism and an editor for *Architectural Review* in 1961, Peter Reyner Banham remarked:

> Architects have relinquished control of the mind of design to theorists and critics from practically any other field under the sun... [I]n Britain they tend to come from an industrial background, like Peter Sharp, John Chris Jones or Bruce Archer, or from the pop-art polemics of the ICA like Richard Hamilton.[1]

In late September of the following year, 1962, John Christopher Jones with the aid of Bruce Archer, two industrial designers, organized a design conference to bring together factions from industry, academia, government and the London-based Institute of Contemporary Arts. Only a few years after C.P. Snow's 1959 lectures on "The Two Cultures," which described an intellectual abyss between scientists, engineers and "non-scientists" of the arts, Jones and Archer hoped this conference could catalyze discussions on intersections of creativity and rationality in processes of designing. This 1962 "Conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications" would be received as the commencement of the Design Methods movement.[2]

Yet just prior to this assumed inception of the Design Methods movement, Banham assessed the significance of then-recent design developments:

> The most important branch of design science by the end of the 1950's was undoubtedly Ergonomics, which seemed likely to push matters of taste and aesthetics well into the background....Unlike most words or phrases, which are promoted to the level of slogans or catchwords, Ergonomics has generated little facile optimism,

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[1] Reyner Banham, "Design by Choice," *The Architectural Review* 130 (July 1961, 1961), 69.

[2] Nigan Bayazit, "Investigating Design: A Review of Forty Years of Design Research," *Design Issues* 20, no. 1 (Winter 2004): 20; Richard Coyne, "Wicked Problems Revisited," *Design Studies* 26 (2005): 13; Nigel Cross, "Designerly Ways of Knowing: Design Discipline Versus Design Science," *Design Issues* 17, no. 3 (Summer 2001): 49; GK VanPatter, "Double Consciousness: Back to the Future with John Chris Jones," *NextD Journal: ReRethinking Design* (February 9, 2002), http://nextd.org/02/09/02/index.html. Accessed on March 23, 2006; Philip Steadman, *The Evolution of Designs* (New York : Cambridge University Press, 1979), passim.

> except for a faith that by patient and painstaking research the relationship between men and their tools can be improved. At one level this has meant quite simply the reshaping of the handles of traditional tools, but at other levels it has meant exercises as abstract as the devising of new sets of symbols for the keys on the control panels of computers.[3]

This chapter argues that models of designing, as well as the popularity and promotion of design methods in the UK, were enabled by those interested in advocating for the emerging discipline of ergonomics. Not only were Jones and Archer eager practioners and advocates of ergonomic methods, but channeled through the efforts of the Ergonomics Research Society, ergonomics and design methods found favor among the government, industry, and academics. Within this institutional context, I argue that during the 1950s and early 1960s in the UK humans and machines were either seen as analogous to or as complementary entities in a system of energy and information. In the latter scenario, machines and humans were thought to communicate through information channels and feedback loops according to their use value - each performed an allotted division of labor. Whereas models discussed in earlier chapters were models of human or machine, these are models of human machine interactions. In particular, while information, concomitant upon information theory, was associated with negentropy, humanity was conceived in terms of entropy. Central to this view was that the human task of creativity was construed in terms of disorder.

Communication design was system design; design for communication drove the design of systems.[4] Just as both human and non-human components of a system were to follow a prescribed sequence of actions for maximum safety and efficiency, principles which resulted from ergonomics research, there were sequences of actions prescribed in processes of designing. These sequences, this division of labor, relied on concerns of energy and information in terms of the organization afforded

[3] Banham, "Design by Choice," 71.

[4] Donna Jean Haraway, "The High Cost of Information in Post-World War II Evolutionary Biology: Ergonomics, Semiotics, and the Sociobiology of Communications Systems," *Philosophical Forum* 13:2-3 (1981-82): 244-278.

by selection, storage, processing and transmission. In turn, this organization depended upon a focus on form at the expense of content or substance, at the expense of the materiality of a system's constituent elements and relations. As argued in Chapter Two, cyberneticians attempted to isolate a formal device of feedback common to both animal and machine, regardless that the former consists of proteins and the later of transistors. So too ergonomists and design methodologists tried to isolate formal devices to organize designing that would permit an encompassing vision of the human and nonhuman. Again, this organization concerned the selection, transmission, storage and processing of information.

Furthermore, not only was 'normal' thought conceived in terms of informational capacity and flow, but normative and normal information processing capacities were seen in terms of natural limits. These limits were thresholds, beyond which pathological dysfunctions of information overload ensued. Humans were seen as limited capacity information processors and methods of designing became limited capacity methods of information processing.

Ergonomics Project

During WWII, overseen by the Medical Research Council (MRC), psychologists and physiologists were recruited by the British government to conduct military research. The MRC-sponsored research covered psychological and physiological problems in the stresses and exigencies of total war. As an MRC report recounted, activities involved

> the study of the best means of increasing operational efficiency, safety and comfort of sailors, soldiers and aviators under various environmental conditions, and conversely, the adaptation of ships, fighting vehicles, aircraft and weapons to the convenience and capabilities of those who have to use them.[5]

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[5] Committee of Privy Council for Medical Research, *Medical Research in War: Report of the Medical Research Council for the Years 1939-1945* (London, HMSO,1948): 131.

The former constituted studying physical and psychological skills, vigilance, fatigue, climate and mental testing; the latter concerned creating machines for improved human-machine performance. MRC psychologists and physiologists studied optimal cockpit design and illumination, lighting, scale displays, seating, telescope sight design and the positioning of instruments relative to the adaptable limits of human physiology and psychology.[6]

In 1944, the MRC created the Applied Psychology Unit (APU) at the University of Cambridge (see Figure 4.1) under the direction of Kenneth J.W. Craik (see Figure 4.2).[7] Craik's war work involved the psychological and physiological aspects of humans and control mechanisms in aircraft and tank gunnery systems. Through this research he developed the concept of a human operator as an intermittent correction servomechanism. Sensory devices, Craik asserted, physiologically register misalignment between a sight and target, to which the brain as "a computing system" would respond by reducing the misalignment. A computation was then effected through muscular work producing externally observable effects towards the reduction of the misalignment.[8]

The result of this action, which Craik terms "dynamic equilibrium," is equated with adaptation to environment.[9] Dynamic equilibrium requires "(1) the storage of energy derived from outside, and (2) its controlled liberation."[10] In other words, dynamic equilibrium requires selection

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[6] A. L. Thomson, *Half a Century of Medical Research: Origins and Policy of the Medical Research Council,* Two Vols. (London: Medical Research Council, 1973–1975), vol. 1, 133–146, vol.2, 172-175.
[7] L. A., Reynolds and E. M. Tansey, eds. "The MRC Applied Psychology Unit". In *Wellcome Witnesses to Twentieth Century Medicine,* Vol. 16. (London: The Wellcome Trust Centre for the History of Medicine at University College London, 2003).
[8] Kenneth .J.W Craik,. "Theory of the human operator in control systems. I. The operator as an engineering system", *British Journal of Psychology 38* (1947) : 56-61; Kenneth J. W. Craik, "Theory of the human operator in control systems. II. Man as an element in a control system," *British Journal of Psychology* 38 (1948): 142-148.
[9] Kenneth J. W. Craik, *The Nature of Psychology; a Selection of Papers, Essays, and Other Writings.* (Cambridge: Cambridge University Press), 11.
[10] Ibid., 14.

for storage and processing. The organism selects energy and processes it to maintain equilibrium though appropriate output selection. Processing in turn requires selection and computation:

> [Controlled liberation] implies (a) a sensory device for detecting the disturbance which is to be countered, (b) a computing device for determining the right kind of response to be made, and (c) and effector or motor mechanism for making this response. The whole can be looked upon as an automatic regulating system involving amplification, by which the disturbance produces a reaction equal to or greater than itself, in just the same way as a valve-amplifier uses energy from the electric supply to magnify the feeble electrical oscillations such as those produced by a microphone into ones strong enough to drive a loudspeaker.
>
> The first stage in the process ...is storage of energy in the body...the way in which potential energy is supplied to nerves so that they become capable of transmitting impulses and liberating energy...analogous physical models have been made.
>
> The second stage is the controlled liberation of this energy...
> Most adequate adaptation demands a subdivision of the system into sensory elements capable of detecting the disturbance, computing devices which select the right response-elements or -elements, and effectors or response-elements which restore equilibrium. This division, which is plain in the case of sense-organs, brains, and muscles of animals, is also very clear in automatic technology and automatic control - namely in sensory elements such as photocells, microphones, thermometers and gyroscopes, computing or selecting devices such as telephone exchanges, and effector elements such as relays, power units and their control valves, or explosive charges with detonators.[11]

This division into sensory detectors, computing device and effectors is contingent upon an organism's or mechanism's capacity for energy storage, transmission, selection, and processing. These are capacities displayed by humans and technologies such as photocells, microphones and telephone exchanges.

In turn, organism or machine failures are seen in terms of failures of selection and processing. For example, in a failure Craik terms a "vicious circle,"

> Peripheral nerve injury may set up a barrage of impulses which hyperexcite and dominate internuncial neurons and central pain mechanisms which then produce

[11] Ibid., 15.

sympathetic and trophic changes in the periphery which enhance the stimulation of the peripheral nerves.[12]

Craik explains neurological dysfunction in terms of radio engineering, in terms of the design of the transmission of audio information.

> The common feature in [such] cases would seem to be positive feedback, as the radio engineer calls it, whereby the output of some amplifying system or relay (of which a nerve fiber is an example) can get back into the input so as to increase the effect. A common example is the 'howling back' or oscillations of a public address equipment if the microphone is placed too near the loudspeaker and the volume control is set too high. The resultant oscillations have more than a superficial resemblance to those found in the e.e.g. of the epilectic...You can stop the oscillation 'surgically' by cutting the microphone or speaker leads, or by moving them further apart, or 'pharmacologically' by reducing the amplification of the system or damping it by resistances.[13]

The vicious circle of positive feedback is a failure of processing: "suppose a small voltage is fed back from the output of an amplifier to its input...If this voltage is in the same phase (crest for crest, trough for trough) as the input or signal voltage, the feedback is said to be positive or *regenerative* and the circuit is likely to go into oscillation" [emphasis original].[14] Additionally, neurosis and psychosis are seen as failures of selection: "Neurosis and psychosis may be varying degrees of over-selection and over-emphasis of sensory and emotional aspects of environment, consequent on shock, frustration of strong desire, or conflict between two desires."[15]

The operative form of organization is in terms of selection, transmission, storage and processing. This is form at the expense of substance or content:

> The arguments given above all indicate the importance of form, which is the relation or parts to one another, rather than substance. ...The problem then is 'what

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[12] Ibid., 56.

[13] Ibid., 57.

[14] J. Barton Hoag, *Basic Radio; The Essentials of Electron Tubes and their Circuits* (New York: D. Van Nostrand, 1942), 198.

[15] Kenneth J. W. Craik, *The Nature of Psychology*, 65.

mechanism can we conceive which is sufficiently flexible to respond, as do men and animals, to identity of form despite very wide variations in material?'[16]

Craik died in 1945, at the age of 31, after being knocked off his bicycle. Nevertheless, Craik's pioneering role in the psychological research between engineering and neurology during the war was emphasized throughout the 1950s and 1960s by the developers of the emerging field of ergonomics. [17]

Ergonomics Research Society

In 1949, a group of scientists involved in research into human-machine interaction, and interested in extending the advantages of the interdisciplinarity experienced during the war effort, established the Ergonomics Research Society (ERS).[18] Termed human factors or human engineering in the United States, *ergonomics* is a neologism from the Greek, *ergon*, work and *nomos*, natural laws (see Figure 4.3). As the derivation of the word suggests, the earliest studies to receive the name were concerned with economies of human effort in the operation of machines. For example, ergonomics dealt with complicated electronic and aeronautical equipment developed towards the end of the WWII, some of which taxed the mental and physical capacity of its operators beyond the physiological and psychological limits of operator efficiency. By the end of the 1950s, the term was expanded to cover all forms of relationships between humans and equipment, including purely physical studies of human physiology in machine interaction as well as communicative studies of

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[16] Ibid., 75-76.
[17] Kenneth .J.W. Craik and M.A. Vince, "Psychological and Physiological Aspects of Control Mechanisms with Special Reference to Tank Gunnery: Part 1," *Ergonomics* 6 (1963):1-33, p.1; Kenneth .J.W. Craik and M.A. Vince, "Psychological and Physiological Aspects of Control Mechanisms: Part 2," *Ergonomics* 6 (1963): 419-440.
[18] O.G. Edholm and K.F.H. Murrell, *History of the Ergonomics Research Society* (London, Taylor & Francis Ltd., 1973); Gordon Cumming and Kenneth Corkindale, "Human Factors in the United Kingdon," *Human Factors 11*, no. 1 (1969): 75-80; Patrick Waterson and Reg Sell, "Recurrent themes and developments in the history of the Ergonomics Society," *Ergonomics 49*, no.8 (June 2006): 743-799.

control systems, in which matters of mental capacity and perception of vision were involved [Figure 4.4].

Throughout the late1960s, Craik's successors as head of the APU were all council members of the ERS. For example, in the 1950s, N.H. Mackworth directed research at the APU toward information and memory (see Figure 4.4). Mackworth's successor Donald Broadbent was a major contributor in formulating psychology in information theoretic terms.

Broadbent stated that "human beings can be treated as mathematically equivalent to communication channels."[19] This entails that humans and information channels display a limited capacity (see Figure 4.5):

> Capacity...in communication theory, is a term representing the limited quantity of information which can be transmitted through a given channel in a given time; if we send Morse code with a buzzer we cannot send a dot and a dash at the same time but must send them successively. An array of *x* buzzers would allow us to send *x* dots and dashes at once, provided we had a listener who could distinguish them. The fact that any given channel has a limit is a matter of central importance to communication engineers, and it is correspondingly forced on the attention of the psychologists who use their terms.[20]

It also entails that information is to be thought in terms of probabilities:

> Modern communication theory regards information as increasing not only with the number of messages received but also with decrease in the probability of each message: that is, with increase in the number of the messages that might have been sent....This is of the first importance, because as will be seen, the performance of selective listeners seems to vary with information as defined by communication theory, rather than with amount of stimulation in the conventional sense.[21]

Behaviorist psychology espoused stimulus response models of human behavior, but here it is essential that information is given in terms of selection rather than stimulus.

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[19] Donald E. Broadbent, *Perception and Communication* (New York: Pergamon Press, 1958), 287.
[20] Ibid., 5.
[21] Ibid., 15.

Humans as communications channels are prone to failures when there is a lapse in memory and selection:

> Recall of list 1 and perception of list 2 cannot be performed simultaneously: this means that if list 1 is recalled completely before any attention is given to list 2, the first items of the latter will have faded beyond recall. Any attempt to observe list 2 before list 1 has been recalled will delay the reproduction of the last items of list 1, and so cause failures.[22]
>
> This is without reference to meaning. Due to a limited capacity channel, this situation does not allow for the necessary separation of storage and selection. As the adoption of Von Neumann architecture to digital computers as serial information processors, humans were seen as single channel information processors.

Psychological symptomology is too given in terms of a machine for information processing:

> Let us consider a translating machine. In principle there are a number of ways of building such a machine, all based on the underlying conception of a machine which responds with words in one language when given words in another. At one extreme there is the type of machine which, when given one word, responds immediately with another word. At the other extreme there is the type which waits until a whole sentence has arrived and then responds with a whole sentence. ...
>
> The distinction between short and long sampling systems is common to a number of situations in which information is handled...it would be surprising indeed if their relative value had not be considered in the design of nervous systems...how would such individuals differ?
>
> [individuals] would differ in speed and accuracy on certain tasks... [this] suggests that individual differences in prolonged performance are highly important, and may be related to those differences which have appeared in the past in the clinical diagnosis of hysterics and dysthymics. 170-173

Hysteria and depression are too configured in informational terms, embodied in symbolic machine functioning.

Form, abstractions of the formal properties of phenomena to identify isomorphisms between different domains of phenomena, human and inhuman, at the expense of content, is

[22] Ibid., 235.

sought in a formal device, a communications channel. This is without reference to content, to meaning of communication. As psychoanalyst Jacques Lacan summarizes the situation:

> The Bell telephone company needed to economize, that is to say, to pass the greatest possible number of communications down one wire. In a country as vast as the US, it is very important to save on a few wires, and to get the inanities which generally travel by this kind of transmission apparatus to pass down the smallest number of wires. That is where the quantification of communication started...It had nothing to do with knowing whether what people tell each other make sense...It is a matter of knowing what are the most economical conditions which enable one to transmit the words people recognize. No one case about the meaning...The quantity of information then began to be codified. This doesn't mean that fundamental things happen between human beings. It concerns what goes down the wires, and what can be measured....It is the first time that confusion as such - this tendency there is in communication to cease being a communication, that is to say, of no longer communicating anything at all - appears as a fundamental concept. That makes for one more symbol.[23]

Craik and Broadbent construed norms of thought, as principles of well adapted biological functioning, as machinic standards embodied technologically. Failures were failures of organization: selection, transmission, storage and processing. The normal is opposed to the pathological, disorganized and dysfunctional given in terms of information.

Ergonomics Research Society Promotions

From its founding, the ERS sought venues to advocate for the use of ergonomic results in industrial engineering design. Beginning in the early 1950s, by mobilizing the financial resources of the UK Department of Scientific and Industrial Research (DSIR), the ERS organized conferences to promote the use of ergonomists and ergonomic data in industry.[24] For example, at the1951 ERS

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[23] Jacques Lacan, *The Seminars of Jacques Lacan*, ed. Jacques Alain Miller (New York: Norton, 1988),82-3.

[24] W. F. Floyd and A. T. Welford, *Symposium on Human Factors in Equipment Design [Held at the University of Birmingham, 18th-20th April 1951]* (London: H.K. Lewis, 1954); W. F. Floyd and the Ergonomics Research

instigated and DSIR-sponsored "Symposium on human factors in equipment design," an ERS contributor advocated "a more systematic treatment" for designing worker environments by using ergonomic data.[25] Another ergonomist commented that a "systematic experimental approach or the application of known fundamental data" could "expand the rules of design with reference to the human factor."[26] These ergonomic approaches were positioned against design by "traditional rules of uncertain origin" or "attempts to solve problems...by the 'dog-paddle' method of trial and error."[27] As sociologists Peter Collins and Pierre Bourdieu have noted, emphasizing complaints and intellectual dissatisfaction serve as a prerequisite to altering a field's course.[28]

Ergonomics was attempting to both develop itself as a professional field and establish itself institutionally within academia. In its attempt to establish itself as a professional field, ergonomics proponents advocated its ability to improve worker efficiency. In a project towards an independent disciplinary field, in 1957 the ERS began a peer-reviewed journal, *Ergonomics*.[29] W.F. Floyd was the

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Society, *Symposium on Fatigue* (London: H.K. Lewis, 1953); *Proceedings of the Conference on Ergonomics in Industry, 27-29 September 1960* (London: H.M. Stationery Office., 1961); C.N. Davies, ed., *Design and Use of Respirators: Proceedings of a Joint Meeting of the Ergonomics Research Society and the British Occupational Hygiene Society held at Porton, 5 and 6 july, 1961* (Oxford: Pergamon Press, 1962); Ergonomics Research Society, *Proceedings of 2nd International Congress on Ergonomics held in Dortmund 1964* (London: Taylor and Francis, 1964).

[25] G.M. Morant, "Body Size and Work Space," reprinted in W. F. Floyd et al, *Symposium on Fatigue and Symposium on Human Factors in Equipment Design*, (London: Arno Press, 1977).

[26] H.D. Darcus, "The Range and Strength of Joint Movement," reprinted in Ibid.

[27] G.M. Morant, "Body Size and Work Space," reprinted in Ibid.; H.D. Darcus, "The range and strength of joint movement,"reprinted in Ibid.

[28] Pierre Bourdieu, *Science of Science and Reflexivity*, translated by Richard Nice. (Chicago, IL: University of Chicago Press, 2004); Peter Collins, *The Sociology of Philosophies: A Global Theory of Intellectual Change* (Cambridge, MA: Belknap Press of Harvard University Press, 1998); Randall Lamont, "Three Big Questions for a Big Book: Collins's The Sociology of Philosophies," *Sociological Theory* 19 (2001):86–91.

[29] For the role of academic publishing generally within disciplinary advancement, see Richard E. Abel and Lyman W. Newlin. *Scholarly Publishing: Books, Journals, Publishers, and Libraries in the Twentieth Century* (New York: Wiley. 2002) Stephen McGinty, *Gatekeepers of Knowledge: Journal Editors in the Sciences and the Social Sciences*. (Westport, CT: Bergin & Garvey, 1999); Walter Powell, *Getting into Print: The Decision-Making Process in Scholarly Publishing* (Chicago, IL: University of Chicago Press, 1985).

first editor in physiology.[30] Floyd offered lectures at the Royal College of Art and the Institute of Mechanical Engineers on the need to utilize ergonomics data in industrial and engineering design. In discussing car construction, he notes

> Changes in design appear to have derived mainly from the following sources : engineering developments, *ad hoc* 'improvements' based mainly on intuition and experience, and improvements dictated by ideas concerned with style, sales psychology, and rather inadequate inquiries into consumer preference. As a result very few cars are found to accommodate adequately people of the dimensions actually found in the population.[31]

Applying ergonomic principles to design involved, for Floyd, "(1) the use of basic derived anthropometric data for the creation of the design; (2) validation, or testing, of the design for its effectiveness by suitable techniques."[32] In other words, one selects ergonomic data. This is then tested (processed).

A.T. Welford was *Ergonomics*'s first editor in psychology.[33] A peer of Craik's at the APU, he was later faculty along with Jones in Machester.[34] Welford lauded Craik's contributions.[35] He stated:

> It is attractive and provocative to conceive of thinking as akin to the operation of a computer going through a series of stages in each of which data are taken either from the sense organs or from a memory store to be combine with other data in some kind of computation, and the result is then stored temporarily to be used later with other data in a further computation, and so on.[36]

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[30] O.G. Edholm and K.F.H. Murrell, *History of the Ergonomics Research Society* (London, Taylor & Francis Ltd., 1973), 8, 31

[31] *Proceedings of Conference on Ergonomics in Industry*, 76.

[32] J.S.. Ward and W.F. Floyd, "A Study of School Furniture and Posture," *Annual ERS Conference Proceedings, 1957, Ergonomics* 1(1957): 178.

[33] O.G. Edholm and K.F.H. Murrell, *History of the Ergonomics Research Society*, 31.

[34] W.T. Singleton, "A.T. Welford - a Commemorative Review," *Ergonomics* 40, no.2 (1997):125-140.

[35] A. T. Welford, *Fundamentals of Skill* (London: Methuen, 1968), 24.

[36] Ibid., 237-8

Selection, processing by computation and storage are the operative procedures. Moreover, they are the organizing components of thought, separable by specific stages. A computer is the model for thought (see Figure 4.6).

Finally, K.F.H. Murrell, the founding ERS member who coined the term *ergonomics*, began teaching ergonomics to architecture students in the early 1950s, collaborated on colloquia for engineering designers in industry and established the course "The design of equipment for human use" in the late 1950s.[37] At the same time, led by Murrell, the British Productivity Council (an apparatus consequent on the Marshall Plan and US intervention in postwar economic recovery) hosted a series of seminars for industry and produced a BBC film "Fitting the Job to the Worker."[38] In addition, Murrell authored the first text book on ergonomics, in which he gives special thanks to Jones for the use of unpublished data on dial displays.

Council of Industrial Design and Design Methods Promotions

Sponsored by industry and the UK Board of Trade, the Council of Industrial Design (CoID) served as a subsidiary actor for the ergonomics project.[39] The CoID rendered ergonomics to industry

[37] K.F.W. Murrell, "How Ergonomics Became Part of Design," *From the Spitfire to the Microchip: Studies in the History of Design from 1945* (London, The Design Council, 1985).
[38] Alec Rodger, "Ten Years of Ergonomics," *Nature* 184, no.4688 (5 September 1959): 20-22.
[39] For example, Paddy McGuire examines the political economy of the CoID's involvement in enlisting craft manufacturers in the government's post-war productivity drive, Jonathan Woodham examines the intricacies surrounding its policy for the public education of "good design." See Paddy Maguire "Craft Capitalism and the Projection of British Industry in the 1950s and 1960s," *Journal of Design History*, Vol. 6, No. 2. (1993): 97-113; Paddy Maguire, "Designs on Reconstruction: British Business, Market Structures and the Role of Design in Post-War Recovery," *Journal of Design History*, Vol. 4, No. 1. (1991): 15-30; Patrick Joseph Maguire and Jonathan M. Woodham, *Design and Cultural Politics in Postwar Britain: The Britain can make it Exhibition of 1946* (London: Leicester University Press, 1998); Jonathan M. Woodham, "Managing British Design Reform I: Fresh Perspectives on the Early Years of the Council of Industrial Design," *Journal of Design History* 9, no. 1 (1996): 55-65; Jonathan M. Woodham, "Managing British Design Reform II: The Film "Deadly Lampshade": An Ill-Fated Episode in the Politics of 'Good Taste'," *Journal of Design History* 9, no. 2 (1996): 101-115; See also

as capable of improving worker efficiency and well-being through machine design.[40] The "Industrial division" of the CoID was established in 1949 "to encourage a supply of well-designed products from, and the flow of trained talent to, industry."[41] That same year the CoID launched its periodical *Design.* This too was geared towards industry: as the first editorial announced "this journal begins publication with one purpose, and one purpose only: to help industry in its task of raising standards of design."[42] Both the industrial division and Design were pivotal in promoting ergonomics to industry.

Under the industrial division, W.H. Mayall was appointed officer for capital goods at the CoID starting in 1959 (see Figure 4.7). Employed for the previous 20 years in electrical and aeronautics engineering, Mayall formulated a basic design doctrine that the design objective was the achievement of a functional purpose and the satisfaction of human needs: "any product may be regarded in two ways - in the way in which it performs a specified task, and in the way in which it meets the characteristics of those who use it."[43] Mayall determined that ergonomics could provide the bridge to efficiently unite function and the needs of users.

By lecturing to industry and publishing in engineering journals, Mayall advertised this doctrine. Beginning in 1950, with the support of the London County Council, the CoID had sponsored "design appreciation" courses in educational institutions. In 1960, however, Mayall began

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Jules Lubbock, *Tyranny of Taste: The Politics of Architecture and Design in Britain 1550-1960* (New Haven: Yale University Press, 1995).

[40] Institutional theorist Paul Dimaggio writes: "An institutionalizing organization form requires the help of subsidiary actors. The claims of institutional entrepreneurs are supported by existing or newly mobilized actors who stand to gain from the success of the institutionalization project. Subsidiary actors provide legitimacy to the new organizational form by providing resources that render its public accounts of itself plausible. Recruiting or creating an environment that can enact their claims is the central task that institutional entrepreneurs face in carrying out a successful institutionalization project," 15, from Paul Dimaggio, "Interest and Agency in Institutional Theory," 3-21, in *Institutional Patterns and Organizations: Culture and Environment,* edited by Lynne G. Zucker.(Cambridge: Ballinger, 1988)

[41] Council of Industrial Design, *4th Annual Report, 1948-49* (London, H.M.S.O., 1949), 81-82.

[42] Ibid., 83

[43] P.J. Booker, ed. *Conference on the Teaching of Engineering Design* (London: The Institution of Engineering Designers, 1964): 267.

"Design appreciation courses for engineers," a traveling educational effort in two branches, which included a session for practicing engineers and another for engineering managers. Both courses began with lectures on ergonomics, for, as he explained, "not only is the subject fundamental but it is also the main link, as it were, between the two aims of designing to perform a task and designing to meet human response."[44]

The CoID directly attributed a rise in engineering firms soliciting design advice to Mayall's articles and lectures, which they claimed "have proved to be the most encouraging development in the Council's industrial activities."[45] Mayall's skillful promotion of ergonomics led him to the position of principle CoID speaker for National Productivity Year, a 1963 British Productivity Council program. From electrocardiographs to industrial boilers, Mayall's articles, or "case histories," for *Design* throughout the 1960s promoted the benefits of using ergonomic data and methods in designing.

The promotion of ergonomics by the CoID was made possible through the additional cooperation of ERS members. One of Mayall's collaborators in the ergonomics project was Brian Shackel. A psychologist by training who worked in the APU in the early 1950s, he was asked by the British manufacturing giant E.M.I. Electronics to advise on the information processing capacities of humans for the human interface in air-to-ground guided missiles.[46] He stayed on at E.M.I. to establish one of the first ergonomics labs in British industry. In addition to publishing extensively on the design of control systems for ergonomics journals as well as often for *Design*, Shackel further

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[44] Ibid.

[45] Council of Industrial Design, *17th Annual Report, 1961-62* (London, H.M.S.O., 1962), 26.

[46] D. M. Anderson and D. Beevis, "The Ergonomics Laboratory, E.M.I. Electronics Ltd," *Applied Ergonomics* 1, no. 4, (1997): 228.

promoted ergonomics by teaching at workshops sponsored by industry associations and a "Human Factors in Design" portion of Mayall's courses.[47]

Shackel and Mayall wrote an article entitled "Control Loop Concept" for *Design* in 1961. It is exemplary of their design method for ergonomically-based human-machine systems (see Figure 4.8). The "cybernetic concept" of the control loop is that information from a display signals an operator, who receives, interprets, and decides an action to output as instructions back to the machine. The machine's control system in turn alters the display. An error-controlled loop continues until the display matches the operator's requirements.[48] As in Craik's model, humans operated as negative feedback servomechanisms.

Systems design is communications design. This organization is given in terms of selection, transmission and processing. The "communication channels" must be "free of interference [and] signal strength must be sufficient for recognition and interpretation," extraneous distractions on the display panel are to be kept to a minimum.[49] Elsewhere Shackel wrote: "For comprehensive design...the only sure guide is thorough study during the design stage of all the expected man-machine information-flow patterns."[50] The ergonomist maps flows of information processing behaviors and designs based on the limits of human information processing: "The relative functional efficiency of a design can be derived by analysing the sequence, speed and especially the errors in the information flow from the machine to man and back to machine."[51] The norms of designing are

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[47] P.J. Booker, ed. *Conference on the Teaching of Engineering Design*, (London: The Institution of Engineering Designers, 1964): 272.
[48] W. H. Mayall and B. Shackel, "Control Loop Concept," *Design* , no.148 (April 1961): 44.
[49] W. H. Mayall and B. Shackel, "Control Loop Concept," 44.
[50] B. Shackel, "Control Rooms," *Design,* no. 133 (January, 1960), 35
[51] Ibid., 29

norms of information processing and the norms of information processing are naturalized in terms of human information processing limits.

Just as the controller must have a machine designed with appropriate placement of information displays and control switches so that the necessary sequencing of actions avoids error, the designer can only design without error if the design information is appropriately placed and sequenced. Thus the "control loop" serves as the basis for design analysis.[52] "Where controls and displays are used in a sequential manner, they should be laid out in a sequential pattern….the arrangement should be firmly based on the operating sequence," so too stages of logical design procedures.[53] Each element of the sequence of the human-machine system's operations "is analyzed to give a step by step diagram of every detail of the process…..By developing his approach step by step…the designer will then have available a rational analytical basis to begin the task of integration from which his final design will emerge."[54]

The historian of science Georges Cangulliem summarized the shift from Taylorism to ergonomic psychology as: "a living thing is not a machine that responds by movement to stimuli, it is a machinist who responds to signals by operations."[55] Information processing determines the nature of human-machine interaction.

John Christopher Jones: From the Design of Systems to Systems of Design

Commemorating the Great Exhibition of a century prior, the 1951 Festival of Britain was to generate optimism for Britain's future after the economic hardships of WWII. Fresh from studying

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[52] W. H. Mayall and B. Shackel, "Control Loop Concept," 44.
[53] B. Shackel, "Control Rooms," 33.
[54] Mayall and Shackel, *Control Loop Concept*, 48.
[55] Georges Canguilhem, "The Living and Its Milieu," trans. John Savage, *Grey Room*, no. 3. (Spring 2001): 19.

electrical engineering at Cambridge, Jones was instated as part of the nearly 50% labor increase the CoID required to orchestrate the Festival.[56] After duties for the festival were over, Jones post as design assistant was disbanded, but he retained his ties to the CoID by writing numerous articles for *Design*. Throughout the 1950s, these articles covered developments in ergonomics.[57]

However, Jones' most significant articles were contained in a series titled "Automation and Design."[58] In these he proposed that the future of the economy lie in automation, the essence of automation being "wide and fast information channels."[59] In particular, "processing units" process information.[60] These units Jones segmented entirely from the selection and transmission of information, which Jones assigned to input and output devices: "a most striking and important characteristic of automation [is] the fact that it is sharply divided into two distinct parts; the central mechanism where the automatic processes take place and the input and output devices which provide contact between people and the system"[61] (see Figure 4.9). Selection works in input devices and transmission operates through output with processing in the central mechanism.

Information is given in information theoretic terms. Jones equates information with energy and understands that information is negentropy, a measure of the amount of information contained within a system: "Information, itself, the basic ingredient of automation, can be mathematically

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[56] Council of Industrial Design, *6th Annual Report, 1950-51* (London, H.M.S.O., 1951), 31.

[57] J. Christopher Jones, "Fitting for Action 2," *Design* 137: 49-52.; J. Christopher Jones, "Anonymity and Repetion," *Design* 98 (, 37-41.; J. Christopher Jones, "The Ergonomic Approach," *Design* 72: 34-37.; J. Christopher Jones, "Crane Cabs for the Steel Industry," *Design*, no. 100: 54-55.; J. Christopher Jones, "Ergonomics: Human Data for Design," *Design* 66: 14-16.

[58] J. Christopher Jones, "Automation and Design 1," *Design* 103: 27-30; J. Christopher Jones, "Automation and Design 2," *Design* 103: 15-19.; J. Christopher Jones, "Automation and Design 3," *Design*, no. 196:, 44-47.; J. Christopher Jones, "Automation and Design 4," *Design* 108: 50-55.; J. Christopher Jones, "Automation and Design 5," *Design* 110: 42-46.

[59] Jones, *Automation and Design 4*, 53

[60] Jones, *Automation and Design 1*, 30

[61] Ibid., 28.

described as the absence of randomness."[62] This separation between selection, transmission, and processing - between input, output and central unit - constructs humanity as equated with variability, entropy and randomness. This separability of selection, transmission and processing means the ability to segment the human and inhuman according to randomness and order.

Human variability is opposed to the order of automaticity, so that human variability is seen in terms of its opposite.

> The difficulty is that automation demands a continuous flow of identical material and always tends to this condition, whereas human requirements are inherently and characteristically various and random and lose their humanity as soon as they are regimented. The solution that has been reached hinges on the fact that a continuous flow can be formed by a row of dots or units. When these are taken together they form the ideal automation medium and when they are taken separately they can represent the variations of human requirements. This is symbolized in the paper tape. It will be seen that the dots are a random manifestation of some human characteristic whereas the rows in which they are aligned and the paper tape itself are continuous. All input and output devices are a means of imprinting the randomness of human requirements on a continuous flow of electrical impulses or pieces of paper.[63]

Human nature, "inherently," is redefined in terms of disorder, as negative information. Humanity substitutes for entropy in the mathematical theory of information. Humanity is defined as automation's absence (see Figure 4.10).

Jones sees the future of design particularly in terms of the input and output devices, and these in turn are to be "biotechnic," following Lewis Mumford's vision of an organically derived technological utopia.[64] This shift to automation will require a shift in design methods:

> To design in this calculating and exacting way is to a great extent rational, logical and inhuman, as is the world of nature which forms a model of what such impersonal

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[62] Jones, *Automation and Design 5*, 46

[63] Jones, *Automation and Design 2*, 15

[64] Lewis Mumford, *Technics and Civilization* (London: Routledge, 1934), 212-67, 281, 354, 400; see also Robert Casillo, "Lewis Mumford and the Organicist Concept in Social Thought," *Journal of the History of Ideas*, Vol. 53, No. 1. (Jan. - Mar., 1992), 91-116.

> designs might be like. This tremendous rationalism, that of nature itself, seems to underlie and prevail in every aspect of automation that has been described.[65]

To design such "biotechnic" forms are to follow nature, and to follow nature means "intuitive designing will be replaced by arduous and exactly analytical methods."[66] Norms of design conduct are to be naturalized.

Ergonomic Method

Integral to a utopian future of automation was for Jones the role of ergonomics. "When I heard of the formation of the Ergonomics Research Society (in the mid 1950s) I wrote to ask if I could join it. As I was not qualified in psychology or physiology they admitted me as one of their first industrial members."[67] Jones published several articles in *Ergonomics*, ranging from investigations into optimal dial sizes to overall concerns in the design of human-machine systems. He was active in leading various ERS committees, and contributed to a series of popular ergonomics pamphlets sponsored by the DSIR.[68]

After the Festival of Britain, Jones took a post as an apprentice at Metropolitan Vickers Electrical Company. Metro Vick's chief electrical engineer permitted Jones to start an ergonomics laboratory at their sprawling research and manufacturing campus, Trafford Park, outside of Manchester. Responsible for persuading departmental engineering designers and chief engineers of the merits of his suggestions, he was only occasionally successful.[69] Part of these suggestions to

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[65] Jones, *Automation and Design 5*, 45

[66] Jones, *Automation and Design 2*, 18

[67] Korean Society of Design Science, "10th Anniversary Conference, 15-16 October 2004," http://www.softopia.demon.co.uk/2.2/early_days1.1.html, Retrieved July 27, 2006.

[68] J. Christopher Jones, *Layout of Work Spaces* (Ministry of Technology: HMSO, 1967). This series of 12 ergonomics pamphlets were popular enough to go into a second printing.

[69] J. Christopher Jones, Interview with author, March 17, 2006.

engineering designers was to use ergonomic data in their design process. As Jones construed it, much of the reason for the rejection of ergonomic considerations lay in the engineering design process itself.

> I did this ergonomics study of how the designing was done purely with the view of getting the ergonomic information...into the engineering decision process at the point where it wouldn't be rejected - so the human limitations would come first and the machine limitations would come second.[70]

Utilizing an ergonomic approach required a "systematic sequence of decisions and tests" for "better fit between equipment and user."[71] Yet Jones observed that engineers worked largely, as he termed it, intuitively. "Intuition," for Jones, is opposed to "the essentially ergonomic method of systematic testing."[72]

To understand Jones systematic design method it is necessary to understand an approach in ergonomic research, a method for gathering ergonomic data devised in the UK during WWII to build aircraft cockpits to fit pilot dimensional variability. Knowing the tasks a pilot would have to perform, subjects would sit in an appropriately simulated cockpit. Experimenters would vary cockpit layout dimensions based on body measurements and record subjective measures of fatigue and comfort, from which limit ranges of comfort were constructed (e.g. span from shoulder to throttle not more than a certain amount and not less than a certain amount).[73]

To generalize this approach, Jones offered that in "fitting trails," one is to (1) list "factors likely to influence the way in which dimensions of an area could affect the comfort or performance of the user," (e.g. "What degrees of body motion are compatible with carrying out the actions with

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[70] Quoted in C. Thomas Mitchell, *Redefining Designing: From Form to Experience* (New York: Van Nostrand Reinhold, 1993), 40-1.
[71] J. Christopher Jones, "Fitting Trials," *Architect's Journal* (6 February 1963): 321-325.
[72] J. Christopher Jones, "The Ergonomic Approach," *Design,* no. 72, 34.
[73] G.M. Morant, "Body Size and Work Space," reprinted in Floyd and others, *Symposium on Fatigue and Symposium on Human Factors in Equipment Design,* 17-24.

the required efficiency and with a tolerable degree of comfort?")[74] (2) Construct a simulator for which the designer as subject can adjust model of artifact settings compatible with the initial factor list, "to establish the importance each dimension in relation to the user's actions." [75] (3) Vary the artifact layout to establish limits of "tolerance ranges" for all predicted users.[76]

In the ergonomic fitting trial method, one is taught to predict user functions, build a simulator and devise tolerance limits (see Figure 4.11). Error controlled feedback is how the tolerance limits are devised, the actual effect of ranges of movements brought within the determined limits of effect using the error - amount outside physiological comfort - to achieve the desired effect. If outside the determined limits, the designer makes the appropriate change to the simulator, to eliminate the error of deviation from the tolerance ranges of human comfort. This is error controlled, because the measurement of error feeds back into achieving the artifact's goal of permitted movement range. The goal of the artifact is maintaining homeostasis of the human within the limits of adaptation. The user's subjective experience is quantified by devising human limits relative to the object's potential positions to find the optimal range of standardization for the product. Humans and machines are blurred in terms of selection and processing: Input is selected based on observation and processed according to negative feedback.

Ergonomics Method Becomes Design Method

In 1957, after Metro Vick had been purchased by Associated Electrical Industries (AEI) Ltd, Jones developed the control consol for the first transistor-only digital computer in Europe (see Figure

[74]eg "1. What are the user's purposes or objectives?", "14. What degrees of body motion are compatible with carrying out the actions with the required efficiency and with a tolerable degree of comfort?" Jones, "Fitting Trials," 322.
[75] Ibid.
[76] Ibid., 325.

4.12). The engineering specification for the AEI 1010 considers the consul for "central control and monitoring."[77] The computers inputs are said to be "fed" by the controller, the outputs require controller actions (see Figure 4.13).[78]

Jones converted the design of the AEI 1010 into his first systematic design examples. The design method begins with a list of locations people may occupy and functions to be performed in relation to the computer consul. These locations and functions, through a combination of prediction and material "experiments to simulate operational procedure," are then placed in a matrix, a chart of interactions linking potential behaviors of people and objects in the control room. For example, for "seated operator - computer: whole of computing machine area visible from normal direction of view. No obstructions above 10 degrees."[79] Through this listing of performance specifications or "p-specs," the individuals and the demand of tasks are specified as subsystems to be optimized (see Figure 4.14). Each p-spec is associated with a limit solution given by the tolerance limits, or "partial solution," with "no reference to shape."[80] The design method differs from the ergonomic research method insofar as one solves for each "partial" solution. These partial solutions are combined into a final solution, with the provision that the limits necessary in each partial limiting solution are not violated.

The task decomposition of the user's functions provides problem decomposition. The physiological and psychological limits of each interaction relative to the artifact permit a design problem to be solved for the limiting solution. Goals of design are given in terms of boundaries for

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[77] J.Christopher Jones, "AEI Industrial Design Course 1961: The Design Process," 2, Box 1, Item 2, vol. 1, 1950-1960, John Christopher Jones Collected Papers, Ms89-023, Special Collections, Virginia Tech, Blacksburg, VA. Hereafter SCVT.
[78] Ibid.
[79] Ibid., 6.
[80] Ibid., 5.

determining information and material, psychological and physiological, limits. Natural limits become norms for design.

Jones' "manual methods" of logical operations are in preparation for task allocation to computers.[81] Jones use of a matrix method mimicked the decision tables of decision theory (see Figure 4.15). Indeed, this method of design is not dissimilar to the operations of the AEI 1010, for which

> Each step in an instruction requires the selection of the appropriate circuits to execute the step, a delay to time the operation of the step, and a step-on circuit to select the next step. At the expiry of the selected delay, a timing pulse is applied to the control unit to move it on to the next step. These pulses also drive the data from point to point in the computer along the paths selected for that step. Certain steps involve a choice of action following a decision which is made as a result of a test.[82]

Stages are logical representations of normative instructions to induce specified decisions and subsequent actions (see Figure 4.16). Just as the requirements are to be placed before the machine controller in an orderly presentation for task action, "when the information may be too disorderly to reveal any general pattern" one uses interaction charts and matrices to guide the decision making process. A formal device is sought for the selection and processing, transmission and memory of design organization. This formal device is explicable in terms of the organization of information. Altering between organizing information and generating decisions based on these information organizations, selection and then processing, stages are required when a "process involves far more alternatives than the memory can handle without confusion."[83] This is like Broadbent's theory of humans as limited capacity information processors. It is also similar to the AEI 1010, for which

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[81] J. Christopher Jones and D. G. Thornley, *Conference on Design Methods: Papers Presented at the Conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications, London, September 1962* (New York: Pergamon Press / Macmillian Company, 1963), 71.
[82] J.C. Gladman, "AEI 1010: A Computer for Commerce and Industry," AEI Engineering (April1961): 150.
[83] ibid., 66

> The complete cycle of selection of a buffer store and transfer of one word into the working store is about 26 μsec, but while a word is being transferred from one buffer the search for the next is in progress, so that the net rate of transfer of data is therefore a little more than 77,000 words per second, and if a greater rate than this were to be demanded by an assembly of peripheral units, some loss of data would occur.[84]

Jones began teaching the initial form of his 'systematic design method' to engineering designers at AEI. Evening classes to section leaders from engineering design and drawing offices were preceded by a component of 'experimental aesthetics.' Following a variant of the Bauhaus basic course,[85] students were encouraged to create color montages and abstract structures from building materials (see Figure 4.17), study nature's engineering of a marsh reed, and screen Eames' *The Information Machine*. This film asserts that to engage with computers in the process of designing one must essentially think like a computer. As the film states:

> The calculator provides creative man a higher platform upon which to stand and upon which to work. Data processing removes the drudgery, but imposes new and broad responsibilities. The designer must be able to state precisely what it is he needs to know. This is not always so easy. He must formulate a general plan of procedure. This plan or program takes the greater part of all the time involved. He must write a concise step by step list of instructions, translated into a digestible code, and feed it to the computer. Then he must provide the machine with all pertinent background information and related data. The preparation may have taken months, the actual calculation hours or even minutes. But once set up, it can attack the problem with infinite variations and trustworthy memory.

However, while the use of computers in design was appealing, there was also a U.S.-based concern with conformity was heralded by sociologist David Riesman in 1950 and Martin Mayer of *Esquire* in 1958 that fellow Americans were lacking of individuality and creativity.[86] Captured most

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[84] J.C. Gladman, "AEI 1010: A Computer for Commerce and Industry," 152.

[85] As taught by Victor Pasmore and Robert Adams at the London Central School of Arts and Crafts. Jonneke Jobse, *De Stijl Continued: The Journal Structure (1958-1964) an Artists' Debate* (Rotterdam: 010 Publishers, 2005), 51-52. Jones sited Adams in particular. Interview with author, March 17, 2006

[86] David Riesman, *The lonely crowd; a study of the changing American character* (New Haven: Yale University Press, 1950); Martin Mayer, *Madison Avenue, USA.* (New York: Harper, 1958).

harshly in Fortune editor Whyte's 1956 *The Organization Man*, Whyte asserted that a regimented economy of corporate efficiency was causing an America of identical, uncreative conformists. An explosion of US government sponsored creativity research ensued in the 1950's concern with conformity. Creativity research was posed as pivotal during the cold war. As one psychologist phrased it in 1954, "international annihilation will be the price we pay for a lack of creativity."[87]

"Synectics" was an ideal corporate response to this creativity crisis, "an operational theory for the conscious use of the preconscious psychological mechanisms present in man's creative activity."[88] Devised by William Gordon, the Cambridge Synectics Group found funding and support through the Department of Defense, MIT, Harvard and the Rockefeller Foundation.[89] Jones favors these techniques of operationalized creativity, Synectics and Brainstorming, its "trade" instantiation. As Gordon writes:

> One way to look at group problem solving is to consider the group as a communications network. Each individual taking part in the discussion receives messages and can also originate them. The group responds as a whole so that responses are composed by several sources. This is similar to a kind of spontaneous amplification where messages in reply to the original question are transmitted as though they emanated from a single source, when actually five or six separate individuals are pooling their communicative power. The resistance of the individual circuits must be minimized...When an individual speaks only in a clear logical relation to the previous speech, the result is greater difficulty in synthesizing a new idea from old ones because of his inability to communicate the old ideas on a low-resistance level."[90]

"Synectics" became the operative mode for releasing conscious factors blocking this communications channel. Jones techniques operationalized creativity by generating a "*Random List of Factors*" at the

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[87] Carl Rogers, "Toward a Theory of Creativity," ETC: A Review of General Semantics 11, no.4 (1954): 250.
[88] William J. J. Gordon, *Synectics, the Development of Creative Capacity.* (New York: Harper, 1961), 3.
[89] Gordon enthuses an acknowledgment to Jerome Bruner (see Chapter 3): "Mr. Bruner, more than anyone else, triggered the compliation of this book. He persuaded me it should be written."Ibid., ix.
[90] Ibid.

beginning of "analysis," and "creative thinking," at the beginning of "synthesis." This operationalization works as though creativity is a mechanism selecting on a communications system.

The Ergonomics Laboratory was staffed by apprentices, who had two year educational training and thus did not have to secure a budget for salaries. Nevertheless, Jones' supervisor terminated his teaching, his supervisor "no longer willing to support my making an 'art university'" in the research park."[91] In the early 1960s he was offered a position as head of Design Technology Program at the Manchester College of Science and Technology.

At Jones' program, the areas of research were primarily concerned with "design methods" and ergonomic subjects ("user requirements" and "human performance").[92] The research was partly sponsored by Jones former employer AEI Ltd, Architect's Journal, and the Royal Institute of British Architects. The faculty included a range of psychologists and ergonomists.

1962 Conference on Design Methods

In early 1962, Jones presented a lecture to aeronautics engineering students at Imperial College, London. The lecture concerned the pedagogic method Jones had been developing over the past several years. Following the talk, and animated by the potential for his method, Jones spoke to his friend Peter Slann, to whose students he had just lectured. Jones wished to organize a conference that would address the role of intuition and rationality in design fields. Slann secured a donated space through Imperial College, and together they set about garnering interest by sending

[91] J.C. Jones interview with author, March 17, 2006
[92] "Design Research Report No. 1, 1963-6, Industrial Design Technology, University of Manchester Institute of Science and Technology, "n.p., Box 2, Item 2, vol. 2, 1960-1970, John Christopher Jones Collected Papers, Ms89-023, SCVT.

questionnaires to those they thought might care to present papers or attend.[93] This effort culminated in late September, 1962, at the "Conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications." (see Figure 4.18).

The conference brought a design critic and two ICA affiliated painters together with engineers, architects, psychologists, an industrial designer and a cybernetician. Christopher Alexander was not initially scheduled. However, as Jones recalls, Alexander "arrived at the last minute and we re-arranged the programme so that he could present his mathematical design process for an Indian village"[94] The largest institutional contingent on the conference organizing board were instructors from the Royal College of Art, although there was also representation from Sheffield University, Bartlett, the School of Architecture of University College, London, the Institute of Engineering Designers, Imperial College of Science & Technology, Manchester College of Science and Technology and Manchester University as well as *Design*.

Although not directly sponsored by the ERS, a review of the conferences was penned by an ergonomist reviewing for *Ergonomics*:

> In the wake of advancing technology there have appeared a multiplicity of techniques, theories and methods of design. Their occurrence is one more aspect of the adaptive response of the human to his environment: science presents us with a bewildering number of alternative ways of achieving any given purpose, and the adaptive response is to categorize the parameters, systematize the thinking and somehow arrive at a method of selecting the most appropriate solution. Design is, essentially, manipulation of the human environment, and any normal framework which can also be used for the application of the human sciences is obviously relevant to ergonomics.[95]

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[93] Korean Society of Designers, "10th Anniversary Conference, 15-16 October 2004."
[94] Ibid.
[95] B. Shackel, "Review of 'Conference on Design Methods,'" *Ergonomics* 7, no. 4 (1964): 499.

Adaptation is associated with selection and normalcy. Norms here serve as a functional regularity, as the principle of an appropriate and well adapted biological functioning. In this sense the normal is opposed to the pathological, disorganized and dysfunctional.

The presenters varied widely in their disciplines, and willingness to engage with the potential for examining the interactions of creativity and systematicity. Some presenters held that design creativity could not be captured in discrete stages. This was true of two artists loosely associated with the ICA. Painter Howard Hodgkin was interviewed by Roger Coleman, former editor of the Royal College of Art's student magazine *Ark* and associate editor of *Design*, on Hodgkin's views on art pedagogy. Hodgkin offered that only limited aspects of painting can be taught:

> There are skills connected with picture-making which can be taught. Also one can make elementary connections between image-making and perception. To some extent a sensual awareness of the physical or material properties of works of art, can be aroused. The history of art can be displayed.
>
> Not much more than this can actually be taught.[96]

Painter Robyn Denny, and contributing ICA curator, provided an overview of theories of realism, idealism and Buddhist approaches to art.[97]

However, those who advocated design in terms of stages sought a formal mechanism amenable to human and machine functioning. For example, in the conference review by Mayall:

> Computers and computing techniques will be used more and more to solve complex design problems - indeed, this is happening now. Computers store information on matrices, and several speakers showed that we too could use matrix type charts to cross-check the effect of one design factor on another, or even to assess the number of possible solutions to any design problem.[98]

As the conference contributor engineer A.H. Lucas makes clear, matrices order data in a computationally amenable format: "The use of matrices or blocks of data automatically employs the

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[96] Roger Coleman and Howard Hodgkin, "Creative Methods in Painting," 196, in ibid.Hereafter CoDM.
[97] Robyn Denny, "The Creative Process," in CoDM.
[98] W.H. Mayall, "Design by Method," *Design* 166 (October 1962): 37.

inherent instructions of computation contained in the conventions of matrix manipulation"[99] The separation of problems into sub-problems was amenable to the use of the digital computer: "The philosophy of breaking down the structure into elements facilitates ...[the use of]digital techniques rather than analogue."[100] Furthermore, as ergonomic psychologists were concluding that humans, as digital computers, were limited channel information processors who must be presented data in the appropriate order and arrangement for appropriate reaction, Lucas determines that "layout of the basic data is relevant to the means of manipulation."[101]

For the engineer K.W. Norris, "The normal process of designing, whether carried out intuitively or consciously, involves problem DEFINITION, ANALYSIS, SYNTHESIS and PRESENTATION [Emphasis original]."[102] This is translated into a matrix so that one is capable of "coding" solutions. One then selects from the "'store' of solutions."[103] The parameters are to be independent. This is significant because one designs by selection from a memory store. Like a digital computer, no processing can occur in this memory store, it is only open to retrieval.

Design organization was information organization. An engineer at Durham University D. G. Christopherson, spoke of "novelty" in design "selection."[104] As Donald Broadbent phrased the effects of novelty:

> In terms of the filter theory... the filter is biased towards previously quiet channels, and information on busy channels has a lower chance of reaching the perceptual system. In ordinary speech, we attend to an unusual even rather than a simultaneously usual event. The fact is particularly curious because a rare event

[99] A. H. Lucas, "Some Experiences of Structural Analysis with the aid of an Electronic Digital Computer," 142, in CoDM.
[100] Ibid., 147.
[101] Ibid., 146.
[102] K. W. Norris, "The Morphological Approach to Engineering Design," 116, in CoDM.
[103] Ibid., 135.
[104] D. G. Christopherson, "Opening Address: Discovering Designers," 4,5, in CoDM.

> contributes more information than a common event...there seemed to be an undue bias in favor of the unusual event."[105]

This was to be followed by "analysis" or "calculation."[106] The next step was to devise a "main channel of communication."[107] For this communications channel, he announced that "drawing might be dispensed with altogether if what one was communicating with, the controller of the process of the manufacture, was not a man but a digital computer storing the design in the form of a programme."[108]

Another presenter was L.S. Jay, an urban planner with the DSIR's provision the Building Research Station - very much a show place for architectural ergonomics research and assessing optimal lighting configurations.[109] "Planners" he stated "have to face a struggle to apprehend organized complexity in a rapidly changing environment and this calls for an emphatic shift in their thinking."[110]

The problems of the twentieth century were, as Warren Weaver phrased it in 1949, problems of "organized complexity."

> These are all problems with a *sizable number of factors which are all interrelated into an organic whole...*
>
> These new problems, and the future of the world depends on many of them, requires science to make a third great advance, an advance that must be even greater than the nineteenth-century conquest of problems of simplicity or the twentieth-century victory over problems of disorganized complexity. Science must, over the next 50 years, learn to deal with these problems of organized complexity...Out of the wickedness of war have come two new developments thatmay well be of major importance in helping science to solve these complex twentieth-century problems.
>
> The first piece of evidence is the wartime development of new types of electronic computing devices...The second of the wartime advances is the "mixed-team" approach of operations analysis...[Both] are familiar to those who were

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[105] Broadbent, *Perception and Communication*, 84-5.
[106] D. G. Christopherson, "Opening Address," 5.
[107] Ibid., .6
[108] Ibid., 8.
[109] See, e.g., *Proceedings of the Conference on Ergonomics in Industry, 27-29 September 1960.*
[110] D. G. Christopherson, "Opening Address," 12.

> concerned with the application of mathematical methods to military affairs."[111] [emphasis original]

Similar to the Joint Center's uses of a cybernetically turned operations research, Jay advocated for the establishment of an urban research center, reiterating their call for a cybernetic decision structure, feedback for adjustment and establishing new goals.

> The kernel of the planners operational research problem—given the population characteristics, a forecast of their change and a plan—is to construct a control system [for which] two feed-back loops [are] required. One which is activated by the difference between planned and actual achievement in the execution of the plan and one which reacts in accordance with measures of fitness of the plan.[112]

In conceiving a system for urban planning, whether explicitly a computer program or a manual logical decision sequence, the design system is to contain a record of decisions. The planner is then freed by technology from the cognitive constraints imposed by human's information processing constraints (citing Simon), to plan a control system.

> The system must contain a full and accurate record of decisions that are taken and the reasons for them. It must convey positively and on demand all the information that may subsequently be needed about those decisions and the action taken on them.[113]

Urban planning is given in terms of information selection storage and processing through feedback.

Architect Joseph Esherick had in 1961 studied operations research with the prominent operations researchers C. West Churchman and Russell Ackoff. For Esherick, "in design one is concerned with information and then action.[114] "Acting" is defined as that which is "purposeful and functional."[115] Design is communications design: data selection and subsequently processing.

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[111] Warren Weaver, "Problems of Organized Complexity," *American Scientist* 36 (1949): 538-540.
[112] L.S. Jay, "A Systematic Approach to the Problems of Town and Regional Planning," 19, in CoDM.
[113] Ibid, 18.
[114] Joseph Esherick, "Problems of the Design of a Design System," in, 77-79, in CoDM.
[115] Ibid., 79.

Finally, consider Alexander. He presented "The Determination of Components for an Indian Village," a portion of his dissertation. He was scheduled to spend 1963-66 working for the National Design Institute in Ahmedabad, India building a master plan for Bavra, Gujarat - although the built portion of the master plan was a single school house (see Figure 4.19).

For information processing models of design, the physical world contains information and mental faculties are conceived in terms of properties of information-processing systems. This is true for Alexander as well as the other models of design detailed. However, Alexander's approach differs from that of Jones and the ergonomic models of design because the latter pose questions to be answered through empirical investigation, building a model and mapping behaviors to that model, to subsequently adjust the model. For, in something with a sufficient level of complexity, it is simpler to describe the structure by building it than describe its behavior. Thus rather than describing human behaviors mathematically and build a structure accordingly, the ergonomic method creates a physical model and then compares it with observation by mapping human behaviors to the model. As one ergonomist noted in experiments on the design of car seats:

> The practical aim of these investigations is the drafting of recommendations regarding the dynamic properties of seats or, better still, regarding the properties of the system formed by the tyres, the suspension and the seat. The investigation of so complex a system is beyond the present possibilities of mathematical expression and can only be studied by means of electro-mechanical analogies. The results of our work should make it possible, inter alia, to give definite values to the components of the electric circuit used to simulate the dynamic characteristics of human beings.[116]

Rather than the mathematical object as that which is a model or norm of nature, the natural object becomes a norm for the mathematical object. Alternatively, Alexander axiomizes behaviors by posing answers, and creating an architectural system which fits these answers. The next chapter will

[116] *Proceedings of Conference on Ergonomics in Industry, 27-29 September 1960*, 138

concern more fully the implications of models for conceptions of nature and norms in Design Methods.

Chapter 5 - Models and Norms of Information Design, 1963-1965

> But the information comes at night. The communications technology it picks is not the phone or the fax or the E-mail. It is the telex - so its teeth can chatter in your head. The information makes sleep interdisciplinary, syllabus disciplines, and then disciplines unknown or not yet devised: eschatoscopy, synchrodesics, thermodonture.
>
> The information is advertising a symposium of pain. Pains of all faiths and denominations. These are your little ones, these are your pretty ones. Become accustom to their voices. They will grow louder, and more persistent, and more persuasive, until they're all there is.
>
> It is ordinary and everyday. ...
>
> The information is nothing. Nothing: the answer is so many of our questions.[1]

The use-value of Telex, its utility, is a form of electrical communications. Telex is an ideal, a model, of use-value in its partitions of storage (data registration), selection (coding) and transmission (signals). Telex is also an imitation, a copy of all other identical Telex, which assumes a fixed form and processes homogenous matter. Mathematical laws of communication submit matter transmitted and received to specific form. Imposing form upon matter, mathematical laws of communication adapt a fixed form and a constant matter to one another. From continuous variation are extracted fixed relations and regular marks.[2]

A model can serve an imitation or an ideal, that which deserves to be imitated. Recall that a norm can be a model of conduct or a model of functional regulation. As a model of functional regulation, it is opposed to the pathological, disorganized and dysfunctional. As a model of functional regulation, a norm is a model of nature. A model of the process of designing can serve to abstract a fact of "what is" designing, as a model of the nature of design, as a functional norm which imitates the nature of design.

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[1] Martin Amis, *The Information* (New York: Harmony Books, 1995), 340-41.

[2] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. Brian Massumi (Minneapolis: University of Minnesota Press, 1987), 408-9.

To frame the role of models in Design Methods, this chapter considers the place of ergonomics and engineering education agendas in the mid-1960s promotions of Design Methods. This is achieved by examining a series of conferences on engineering education and culminating the 1965 "Symposium on Design Methods." Yet the history of Design Methods becomes problematized when one considers the status of models; problematized because what constitutes a model serves as an ideal and an imitation, a norm of conduct and a norm of functional regulation.

As a norm of functional regulation, design models in Design Methods appealed to both the biological and universalistic basis of cybernetic and information processing models. Yet not only were models of design imitations of the nature of design, but the nature of design imitated the ideal of universalistic, biologically-based information processing models. Such design models became both a universalistic imitation of nature and an ideal of nature.

As a model of conduct a norm is a principle of conformity. As such it is opposed to irregularity, unevenness, deviation and strangeness. This chapter further argues that the regulation of design according to educational norms in engineering design was replaced by the technological regulation of information processing models.

Scientific Versus Design Engineering

From the mid 19th century until at least the 1970s, a schism existed between "scientific" and "design" oriented approaches engineering education in the U.S. and Western Europe. In "scientific" approaches, to quote historian Jonathan Harwood, engineering instructors "were enamored with the methodological apparatus of the sciences, making a point in their research or teaching to deploy the techniques, concepts, laws, data and instruments from one or other basic science."[3] In "design" oriented teaching practice, engineering problems were taken from a practical domain. This approach utilized methods from the sciences, yet educationalists were attentive to economically feasible and practical constraints.[4]

Throughout the 1950s, voices in favor of scientific fundamentals dominated discussions of engineering education.[5] A.P.M. Fleming, head of research, education and a director of Metropolitan Vickers - the firm where John Christopher Jones first devised his systematic design method (see Chapter Four) - typified a scientific approach. In a report christened by the stamp of government at the close of WWII, education for "engineering scientists and development engineers" was to focus on scientific principles. An alternate provision was for "engineer managers." These managers were trained additionally in "design, manufacture, operations and sales."[6] Instruction in "design" was not seen necessary for research engineers; it was considered a province for industrial concern.

At the Manchester College of Science and Technology (MCST), which had long ties to Metro Vick and where Jones would head a Design Technology program, historian Colin Divall found that there was an increased emphasis on abstract and mathematical treatments of engineering subjects throughout the 1950s. Around 1950, for example, students in optional engineering subjects were asked to describe and apply theory to engineering artifacts in industrial use, as in the course "Internal Combustion Power Plant." However, by 1961, none of these optional subjects were focused on

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[3] Jonathan Harwood , "Engineering Education between Science and Practice: Rethinking the Historiography"', *History and Technology 22*, no. 1 (2007): 54.

[4] Richard Whitley, "The Transformation of Expertise by New Knowledge: Contingencies and Limits to Skill Scientification," *Social Science Information* XXVII (September 1988): 391-398.

[5] These were the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers. W.J. Reader, *A History of the Institution of Electrical Engineers 1871-1971* (London: Peter Peregrinus, 1987), 149-154.

[6] Higher Technological Education, *Report of a Special Committee on Higher Technological Education* (London: HMSO, 1945), 6-9.

particular kinds of technology. "Internal Combustion" had been replaced by "Applied Thermodynamics."[7]

However, by the later 1950s this academization of engineering education was met with increasing resistance from those who called for more attention to design skills. Several leading industrialists, representing such mammoth firms as Imperial Chemical Industries and the government province the United Kingdom Atomic Energy Association, voiced that engineers were unable to cope with developing complete designs, particularly the specifications of details.[8][9] Several engineering instructors, primarily at technical schools with strong ties to industry, asserted that design involved students working from the inception of a design through the specification of the details, and that the ability to construct this complete process was necessary for the role an engineer takes within industry.[10] This tension between "scientific" and "design" engineering would culminate in discussions pursuant on the Department of Scientific and Industrial Research's (DSIR) 1963 "Fielden Report on Engineering Design," which was an integral incitement to several meetings and debates, including the 1965 "Symposium on Design Methods."

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[7] Collin Divall, "Fundamental Science versus Design: Employers and Engineering Studies in British Universities, 1935-1976", *Minerva* 29 (1991): 181, 184-94,.

[8] A United Kingdom Atomic Energy Association spokesperson noted "It has been the authority's experience in carrying out large novel projects...that major successes have been achieved by critical attention to details, no less than by the thought an attention given to the original conception of the project...There is a tendency for designs to be spoiled by lack of attention to detail and this often causes difficult and costly rectification work at site that could have been avoided by more rigorous thought at the design stage." *D.S.I.R. Committee on Engineering Design. Engineering Design* (London: HMSO, 1963), 16.

[9] P.P. Love, "A Criticism of the Technical Education of Recently Qualified Engineers," *Proceedings of the Institution of Mechanical Engineers* 170 (1956): 127-133; E. Smith, "Management and the Engineer," *Proceedings of the Institute of Civil Engineers* 10 (1958): 16-17.

[10] S.V. Hayes and S.A. Tobias, "The Project Method of Teaching Creative Mechanical Engineering," *Proceedings of the Institution of Mechanical Engineers* 179 (1964-65):82.

Fielden and After

WWII underscored a differential between US and British labor productivity, highlighted as the two economies integrated in the Allied war effort. Antagonistic industrial relations ruptured during the 1950s, particularly between craft and manufacturing workers and management.[11] British firms attempted to deskill the labor force and integrate American technology and work study methods. This left UK labor productivity in engineering manufacturing less than half that of the US.[12] Concomitant upon poor productivity, the "Fielden Report on Engineering Design" was called by the DSIR to investigate productivity solutions by means of changing engineering education. [13]

The report made a strong recommendation that design courses in engineering required reconstruction. Among the recommendations made in the report was that the DSIR should promote research into new teaching methods and the development of "design manuals."[14] One of government's lead spokespersons for operations research, Solly Zuckerman, advocated for the creation of "data sheets" to bridge "the gap between research and design," - the engineering equivalent of ergonomic data manuals.[15] One of the recommendations the report also made was that the designer must learn to communicate with control systems:

> The detail designer will need to communicate directly with an automatically controlled machine tool. To a growing extent his output will be in the form of instructions on punched or magnetic tape...Many of the problems to be solved are common to the improvement of drafting methods and to the instruction of automatically controlled machine tools...Both will make extensive use of automatic data processing, for example, to store details of common features in a form readily

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[11] N. F. R. Crafts, Ian Gazeley, and A. Newell, *Work and Pay in Twentieth-Century Britain* (Oxford: Oxford University Press, 2007); Steven Tolliday and Jonathan Zeitlin, *The Power to Manage?: Employers and Industrial Relations in Comparative Historical Perspective* (London: Routledge, 1991)
[12] S. N. Broadberry, *The Productivity Race: British Manufacturing in International Perspective, 1850-1990.* (Cambridge, U.K.: Cambridge University Press, 2005), 317.
[13] *D.S.I.R. Committee on Engineering Design. Engineering Design.* G.B.R. Fielden headed the committee.
[14] Ibid., 44, 49.
[15] Ibid., 48.

> available to the designer, to generate complex functions and to approximate them by interpolation.[16]

The communication medium of drafted drawings was to be modeled on the communications of information storage, transmission and processing.

At an Institute of Mechanical Engineers panel on "The Teaching of Mechanical Engineering Design in Academic and Industrial Environments," convened in the wake of Fielden, Jones declared that "the present failings of engineering design occur because designers are slow to supplement or replace the traditional approach with such new...scientific techniques." These were such as taught in Jones' Design Technology course, techniques such as "Systematic design methods, System engineering, Computer optimization, Information processing, Ergonomics...Statistics and design of experiments...Operational research."[17]

This is a universalistic approach to all design concerns. As Jones stated:

> It is hoped that the training given will prove to be of value in development groups, in design management, in design research and in the teaching of design. It is suggested that some of the students will not become designers but 'design technologists'-trained to apply scientific methods to one part of a design problem, and collaborating with other design technologists each of whom is responsible for a different stage of the work. [18]

The principal of the University of Manchester Institute of Science and Technology lauded Jones' Design Technology program as a[19]

> Post-graduate course in the general organization of design as a process distinct from design of any specified type. It appears to us that there are many problems common

[16] Ibid., 46.

[17] J.C. Jones, comment on "The Teaching of Mechanical Engineering Design in Academic and Industrial Environments," *Conference on the Practice of and Education for Engineering Design, Proceedings of the Institution of Mechanical Engineers* 178, pt. 38 (1963-64): 44.

[18] Ibid.

[19] MCST had been upgraded to university status after the Robbins Report. Great Britain. *Higher education; report of the Committee appointed by the Prime Minister under the chairmanship of Lord Robbins, 1961-63.*(London: H. M. Stat. Off., 1963).

> to many types of design. ... We have been trying to develop a course in design which will exploit at least the greater part of the potential of computation...I hope very much that in the course of time we shall succeed in producing designers who understand about design in that sense.[20]

Such statements of the universal capacity of this new design technologic had a close corollary in cybernetic statements. As a leading American cybernetic researcher proclaimed:

> Just as all the categories of knowledge merge implicitly in the human being, just so a fortiori must all scientific disciplines, which are after all but the systematic reflection of these categories, merge in anthropo-simulation in its completest sense; that is, a necessary condition for man's artificial replication of himself is clearly the convergence of all scientific disciplines.[21]

Or as Gordon Pask, a cybernetician who presented at the 1962 "Conference on Design Methods," indicated of his cybernetic computers,

> Precisely the same arrangement of parts in the computer can represent the spread of an epidemic, the spread of rumors in a community, the development of rust on a piece of galvanized iron, and diffusion in a semi-conductor.[22]

As cybernetics was to be the confluence of all science, design methods was to provide a unified approach to design. Such an attitude was conveyed in a statement made by Peter Slann, Jones' co-organizer for the 1962 Conference:

> Design is not a process exclusive to engineering. The formulation of any problem involves the use of existing knowledge, planned in advance to form a firm foundation for knowledge to be acquired, the whole task being accomplished mainly by methodological and systematic thought.[23]

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[20] B. V. Bowden, "The Teaching of Mechanical Engineering Design in Academic and Industrial Environments," *Proceedings of the Institute of Mechanical Engineers*, 178, pt 38 (1963): 40.
[21] Charles Musès, "The Logic of Biosimulation," in Charles Musès, ed. *Aspects of the Theory of Artificial Intelligence* (New York: Plenum Press, 1962): 116.
[22] Gordon Pask, *An Approach to Cybernetics* (New York: Harper, 1962), 32.
[23] Peter Slann, response to M.C. Malherbe and P.J.B. Solomon, "Mechanical Engineering Design Tuition at Universities," *Proceedings of the Institution of Mechanical Engineers* 178 Pt 1, no.28 (1963-4), 800.

What emerged was an attempted universal design advocated by engineers and industrial designers associated with the Design Methods movement. Directing others in their search for designs, systematic design methods could function as a primary discipline. Systematic methods could operate to provide the analytical tools indispensable to the development of design education. The regulation of design according to educational norms was to be replaced by technological regulation.

1964 Conference on the Teaching of Engineering Design

A further meeting convened in 1964 to discuss the course of action to be taken in design education pursuant on Fielden. Here industry, art and engineering concerns sponsored a "Conference on the Teaching of Engineering Design."[24] At this 1964 assembly, W.H. Mayall (see chapter Four) restated his design strategies with ergonomics as the connection between machine function and human factors. R.M. Kay, the head "appearance designer" at Associated Electrical Industries (which had absorbed Metro Vick; see Chapter Four), the architect and industrial designer Misha Black also made the point that design strategies were towards the satisfaction of user needs through ergonomic tactics.

The utility, use value, was conceived in terms of cybernetics and information processing models for selection, storage, transmission and processing. For example, W.F.K. Murrell, who coined the neologism "ergonomics," taught ergonomics to engineers at the Engineering Employer's West of England Association. This is also where the engineer Edward Matchett taught. Additionally, Matchett was exposed to ergonomics at his regular employment at the College of Aeronautics, Cranfield. This college housed one of the first ergonomics programs in academia. Matchett taught

[24] The conference was sponsored by Enfield College of Technology, Hornsey College of Art and the Institution of Engineering Designers.

what he termed a "Fundamental Design Method." This method received wide support from the UK government and industry: it was used by the Imperial Chemical Industries for the design of processing plant machinery, and a variant known as "Problem Analysis by Logical Approach" was used by the United Kingdom Atomic Energy Association for the design of equipment for the Aldermaston Nuclear facility.

Matchett's design method, which he presented at this 1964 gathering, was decidedly cybernetic, a command and control form of design. Matchett proposed his method as "a universal approach which may be applied to any design, by any designer, at any stage of his work" to achieve "controlled evolution of any design."[25] He believed it "enables a designer to organize his knowledge and make far better use of it, since he is made aware of the nature of the design process he has been using subconsciously, and learns how to exercise a far greater degree of control over it."[26]

The psychologist and philosopher K.F. W. Craik's impact on ergonomics must again be stressed (see Chapter 4). For Craik, a "translation" mechanism was said to be responsible for filtering perceptual inputs. This translation enters an internal mental model, from which inferences for possible actions are made by the appropriate mental machinery. A "retranslation" of this model permits the action of an external process. This model of thought envisions a model being manipulated in the mind just as a model is manipulated in the construction of engineering artifacts.[27]

Furthermore, as in a servomechanism directed through negative feedback by the difference between an existing and goal state, for Craik mental activity is directed by the *discrepancy* between

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[25] E. Matchett, in discussion on "The Teaching of Mechanical Engineering Design in Academic and Industrial Environments," *Conference on the Practice of and Education for Engineering Design, Proceedings of the Institution of Mechanical Engineers* 178, pt. 38 (1963-64): 41.
[26] Ibid.
[27]K.J.W. Craik, *The Nature of Explanation* (Cambridge: Cambridge University Press, 1943), 50;
K.J. W. Craik, *The Nature of Psychology,* ed. by S.L. Sherwood (Cambridge: Cambridge University Press, 1966), 72.

an actual situation and that represented as a goal through an inner "pattern" or model.[28] In the invention of new artifacts as well, Craik concludes agents, directed by this discrepancy, use "mental models of a possible event in the external world."[29]

> I have outlined a symbolic theory of thought, in which the nervous system is viewed as a calculating machine capable of modelling or paralleling external events, and have suggested that this process of paralleling is the basic feature of thought and of explanation.[30]

The logical design object is to be, to use Marshall McLuhan's expression, "outered" as the externalization of a previously internal aspect of human thought.

In Matchett's approach, two decisions networks are utilized, corresponding to the design goal and an objective at each stage in a design decision path. The designer directs "attention":

> first to a purely functional network which grows from the 'primary functional need' (the one need which if not satisfied invalidates all other achievement), and then to a superimposed network which grows from the needs of the various life stages involved in the period of time from designing and drawing to servicing the worn or damaged product. 'Fundamental design method' sets out to rationalize this extremely complex situation, and does so in part by separating the two networks except at definite stages in the evolution of a design scheme when they must be brought together. The second network then modifies the tentative decisions reached in the first until, finally, a design is achieved which is not only functionally satisfactory but also compatible with the wide variety of needs arising from the customer, the capabilities and limitations of the manufacturing company, and the constraints imposed by the outside world in the form of laws, standards and customs.[31]

An overall goal serves to control the primary network. A second network adapts to the strictures of the primary control network, by reducing the difference between the initial state and the goal state through a series of intermediary states. Norms of conduct in the manner of "laws, standards and customs" are folded into norms of functional regulation. Norms provides constraints against the goal

[28] Ibid., 90.
[29] Ibid., 91.
[30] Ibid., 121.
[31] E. Matchett, in discussion on "The Teaching of Mechanical Engineering Design in Academic and Industrial Environments," 41.

which must be met to ensure the design stays within this essentially homeostatic limit. If variables are cast outside of homeostatic limits, the organism dies: if the functional goal is transgressed, the network ceases to "grow". As an error controlling process, a second network of design stages incorporates environmental constraints and "grows" to minimize the error between the current state and the goal state. Design information is selected and processed according to a cybernetic machine.

Ever eager to refer to a designer's unconscious "radar,"[32] which Matchett's method is said to make conscious, the perception engineering of ergonomics is evident: "Conditions are created, by use of charts and symbols etc., in which the designer can ...see only that which it is useful for him to see at the particular time."[33] Selection is controlled. Furthermore, Matchett's universal design took as an ideal, was an imitation of, the total symbolic recording capacities of a computer's memory store:

> It should be noted these charts to some extent took the place of sketches which would normally have been produced in such a design study. They also recorded thought which would traditionally be the non-recorded links between sketches. Some normally non-recorded thoughts and factors include the reasons for making a decision, reasons for deciding against a particular course of action, relationships of items in time and sequence, the number of factors influencing a particular characteristic, and the patterns and trends of decision clusters.[34]

"Normal" design activities are replaced by the technical regulation of cybernetic information processing (see Figure 5.1).

Finally, "physical activities and methods of analyzing these, present a useful analogy to mental actions and their analysis."[35] This is a key statement. Like physical processes subject to causal

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[32] E. Matchett, "Design Training in Post-Graduate Courses," in P.J. Booker, ed. *Conference on the Teaching of Engineering Design* (London, The Institution of Engineering Designers, 1964), 253.
[33] E. Matchett and A.H. Briggs, "Practical Design Based on Method (Fundamental Design Method)," in Sydney A. Gregory, ed., *Symposium on the Design Method*, (New York: Plenum Press, 1966), 185. Hereafter SoDM.
[34] Ibid., 186-7.
[35] Ibid., 185.

laws, thought is a mechanical process carrying out computations: one manipulates a model in the mind as one manipulates a model in engineering (see Figure 5.2).

Similarly, W.E. Eder, a co-author with the systems engineer from the 1962 Conference William Gosling, also presented. Eder had overhauled the mechanical engineering course at University College, Swansea (University of Wales). Eder emphasized that "extracting the abstract, unconscious pattern of designing to teach how to use it" is a necessary intermediary step in tying theoretical knowledge to design.[36] In externalizing that which is traditionally held internally, the internal is extracted much as one would crack open a gear box.

The internal model imitates the external model. Yet the internal model was also held as an ideal for the external model, as a model deserving imitation, evidenced by the very attempt to externalize the internal for its replication. To clarify, the historian Jean-Pierre Dupuy has explained the role of models in early cybernetics as follows:

> A model is an abstract form, as it were, that is embodied or instantiated by phenomena. Very different domains of phenomenal reality—hydrodynamics and electricity, for instance, or light and sonic vibrations—can be represented by identical models, which establish an equivalence relation among them. A model is the corresponding equivalence class. It therefore enjoys a transcendent position, not unlike that of a platonic Idea of which reality is only a pale imitation. But the scientific model is man made. It is at this juncture that the hierarchical relation between the imitator and the imitated comes to be inverted Although the scientific model is a human imitation of nature, the scientist is inclined to regard it as a "model," in the ordinary sense, of nature. Thus nature is taken to imitate the very model by which man tries to imitate it.[37]

Design was incarnated in information processing models as a model of nature. As norms of functional regulation, design models were posed as an imitation of the nature of design. But the (internal)

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[36] W.E. Eder, "Mechanical Engineering Design," in P.J. Booker, ed. *Conference on the Teaching of Engineering Design* (London, The Institution of Engineering Designers, 1964), 193, 201.
[37] Jean-Pierre Dupuy, *The Mechanization of the Mind: On the Origins of Cognitive Science* (Princeton: Princeton University Press, 2000), 29-30.

nature of design was also taken to imitate the (external) model by which the designer tried to imitate it.

1965 Symposium on Design Methods

A 1965 "Symposium on Design Methods" was organized as a continuance the 1964 meeting "Conference on the Teaching of Engineering Design." The proceedings editor and primary organizer of the 1965 Symposium was the chemical engineer S.A. Gregory. Tying models to neurological considerations,

> Internal models are patterns in the head, either preconscious or conscious. These are presumably provided with raw material through the modalities of perception...and developed upon neural nets...Small and insignificant pictures become linked with others to form considerable structures. According to a person's inbuilt facilities and his training and experience the mental process is able to deploy a range of preconscious and conscious problem-solving methods. The individual then carries out some action directly or communicates with others.[38]

Internal models are patterns in the brain, traced from perception to decision to action and communication. Yet external models parallel internal models: "They [both internal and external models] either represent to some degree things or events which exist or are believed to exist or have taken place, or they represent things or events under consideration for the future."[39]

Mapping multiple external signals to a single internal informational container, Gregory states that "the essence of representation is that the model [internal or external] should contain the same amount of information as the original"[40] Like information theory, in which the informational content of a transmission is given in terms of negative uncertainty, what impedes this representation

[38] S.A. Gregory, "Models in Practical Design," in SoDM, 145.
[39] Ibid.
[40] Ibid., 148.

is that uncertainty is negative information.[41] Uncertainty derives "from the human requirement to simplify in order to be able to deal with situations."[42] That is, uncertainty from lack of information stems from the limits of humans as information processors. The potentials for design errors stem from informational uncertainty: "For the engineer, the uncertainty reigning in each of the model situations leads to the need for some risk to be taken in practical work."[43] Information processing as design is focused on improving design as a source of productivity, between knowledge sources of design and the application of design to better knowledge generation and design.

At the 1965 symposium, Jones is quite clear on the equation of design methods and information organization.

> The common feature of the so-called systematic methods of designing (they are really methods of handling design information) is that they permit a widening of the area of search for interpretations of the problem and for solutions to it.[44]

The designer searches for problems and solutions in terms of information. Jones distinguishes between "mental structure" and "analogue structure." The mental structure, "the structure of the classification scheme," is "the pattern of experience and ideas that is available to a designer when he examines a problem or considers a solution." "The structure of the thing classified," is the "analogue" structure, "the patterns of external symbols or models which the designer uses to represent the structures of the situation, the solution or the resources."[45]

According to this historian of science Georges Canguilhem, one of Gregory's references in the 1965 Symposium,

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[41] "Shannon preferred to use uncertainty as a measure of information content: in a situation of much information there is little uncertainty and vice versa." Ibid.

[42] Ibid.

[43] Ibid.

[44] SoDM, 304.

[45] Ibid., 303.

> The model has for a long time simultaneously resembled the type and the scale model, the norm of representation and the change in scale of size. It seems to us today that the explanatory model, an integral replica, be it concrete or logical, of the structural and functional properties of the biological object, has been relegated to the rank of myth. On the side of function, the model tends to be presented as a simple imitator, which reproduces a performance, but by methods of its own. On the side of structure, it can at the most present itself as an analogy, never as a double. It is, then, on analogy that the model method in biology rests, whether the models be mechanical or logical ones.[46]

Analogue as analogy works as a translation. Yet for Jones there is transposition between internal and external. In Friedrich Kittler's words,

> Whereas translation excludes all particulars in favor of a general equivalent, the transposition of media is accomplished serially, at discrete points. Given Medium A, organized as a denumerable collection of discrete elements $E_a^1 \ldots E_a^n$, its transposition into Medium B will consist of reproducing the internal (syntagmatic and paradigmatic) relations between its elements in the collection $E_b^1 \ldots E_b^m$. Because the number or elements n and m and the rules of association are hardly ever identical, every transposition is to a degree arbitrary, a manipulation. It can appeal to nothing universal and must, therefore, leave gaps. The elementary, unavoidable act of EXHAUSTION is an encounter with the limits of media.[47] [emphasis original]

This is a transposition between the internal and the external because it is accomplished at discrete points:

> The designer may be thought of as a circuit that is capable of damping small signals of mismatch between the structures of the classification scheme [the internal mental structure] and the structure of the thing classified [the external analogue structure].[48]

When the mismatch of structures is ameliorated, when these structures match (contra Kittler's insistence on limits), this stage in the design problem is terminated. The designer then continues this iterative search behavior until the next subproblem is solved. The image is a nervous system which

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[46] Georges Canguilhem, "Models and Analogies in Biological Discovery," in A. C. Crombie, ed. *Scientific change: Historical studies in the intellectual, social, and technical conditions for scientific discovery and technical invention, from antiquity to the present* (New York: Basic Books, 1963): 520.
[47] Friedrich A. Kittler, *Discourse networks 1800/1900*, trans. Michael Metteer (Stanford, CA: Stanford University Press, 1990), 265.
[48] J.C. Jones, "Design Methods Reviewed," in SoDM, 302.

takes inputs, sorting them into appropriate assemblies based on reducing the mismatch of identity between internal and external.

Jones' postulates design on the model of a Turing machine. In a Turing machine, the input to the head is the tape of the machine at the given moment, the pair constituted by the internal state and the external state, the content of the square being scanned. The output is determined by the input and consists in either changing or retaining the internal state, changing or retaining the content of the scanned square, and shifting or not the position of the head right or left. The machine then halts, for certain inputs.

For Jones, the internal state works like the mental structure, and the content of scanned square the analogue structure. The designer in Jones changes or retains the internal or external state, and then proceeds to the next step, halting upon completion of the design. In turn, this isomorphism has a further isomorphism in that the tape serves as the memory for the machine. The read-write head is the memory bus for transmission purposes through which data is selected according to the table of processing rules.

Design methods were information processing. For example, Ronald D. Watts, a Lecturer in Instrumentation and Measurement at City University, London, proposed at the 1965 Symposium a device for sorting relevant design information from "noise". Excessive information must be dealt with by a filter device. "The designer acts as a perceptive filter, deciding what is and what is not relevant to the particular circumstances"[49] (see Figure 5.3). This item in the perceptual machinery selects and processes information into sets of functional components, allocated into subsystems of functional interrelations. Considered "autonomic" or self-regulating decisions, feedback from the

[49] Ronald D. Watts, "The Elements of Design," in SoDM, 87.

environment necessary before the designer proceeds, the designer seeks a "set of solutions from which the optimum can be selected."[50] "It is evident that [the designer or design team] is an information-processing agent seeking conciliatory relationships over a large set of elements, or facts, and that these change as the design progresses."[51]

Additionally, consider C.H. Buck, a product design lecturer at University of Aston in Birmingham contributed a model of the commercial function of design in industry: "for efficient communication it is necessary to introduce a great deal of redundancy and feedback in order to increase the signal-to-noise ratio to an acceptable level."[52] Humans are the source of noise, as the lapse of the computer, generated through "human variability and human imperfection"[53]

For A.D. Newman, a Scientific Officer with the Ministry of Technology, informational coding, storage and retrieval provides design analysis and synthesis - coding the selection of concept structure for the representation of information. Relations between concepts during synthesis are based upon recognition, cognition, short term and long term memory.[54] This informational structure concerns symbolic representations of information, for which locating appropriate rules "for combining two known items of information" are capable of providing "a new mathematical logic of induction or creativity." The relational structure for a design problem is to match the psychological processes inside the head. "Formalization of the creative task can be achieved only by understanding and imitating mental mechanisms"[55] Causal laws of nature parallel the mechanical laws of though. Humans and machines are equivalent (see Figure 5.4).

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[50] Ibid., 88.
[51] Ibid., 90.
[52] C.H. Buck, "Communication," in Ibid.., 285.
[53] Ibid., 282.
[54] A.D. Newman, "Patterns," in Ibid.., 101.
[55] Ibid., 103.

However, for the architect Geoffrey Broadbent, who will come to play a key role in Chapter Six, "current design methods are less efficient than they might be because they fail to build in the 'unreliability' of the human operator, which is the only real source of creative ideas, good or bad."[56] Humans are given the task allocation of creativity in terms of disorder. "The brain will be superior" in the "association of ideas and the generation of unpredictable relationships"[57] However, this unreliability can be simulated though a black box model of creative behavior: information is input, "transmitted in any perceptual system," into a black box containing a memory of "accumulated information" and through a stochastic function (to simulate human unreliability as randomness), an output of "creative behavior" is generated.[58]

Finally, at the 1965 symposium, Mayall again stressed the importance of design satisfying user needs through the use of ergonomic research.[59] As in the 1964 meeting, Eder further emphasized tying the abstractions of theoretical engineering into design practice through "outering" internal thought processes.[60] The ergonomist Brian Shackel (see Chapter Four) presented his conical method of human-systems design: First, define the system goal. Then, "human elements" and "machine elements" are assigned subtasks relative to the goal of optimizing the overall system's performance. Next, by studying human and machine decisions and subsequent actions in terms of informational inputs and limitations optimize the interaction at each interface of humans and machines (see Figure 5.5).[61]

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[56] Ibid., 110.
[57] Ibid., 112.
[58] Ibid., 115.
[59] W.H. Mayall, "Design and Human Satistfaction," in Ibid., 39-44.
[60] W.E. Eder, "Technologies and Varieties of Design," in Ibid., 311-315.
[61] B. Shackel, "Ergonomics and Design," in Ibid., 52,55.

The commonality of these approaches lies in the use value of isomorphic models, the abstraction of useful properties of phenomena and their identification between the domains of human and machine. The isomorphisms exist between humans and machines on two levels. One, an internal model is manipulated in the same way as an external, engineering model, in the same way as the model of a machine. Thus the nature of design comes to imitate that which is to be its model. Two, both internal and external models are models given in terms of information. In short, "design may be seen as essentially an information processing system."[62] However, as Gilbert Simondon observed in 1958:

> Information is ... midway between pure chance and absolute regularity. One might say that form, conceived as absolute regularity, both spatially and temporally, is not information but a condition of information; it is what accommodates information . . . But information is not form, nor a set of forms; it is the variability of forms, the contribution of variation in relation to form. It is the unpredictability of variation in form, not the pure unpredictability of variation in general.[63]

What happens when information takes the form of average, and in turn average is equated with normalcy, is dealt with in the next chapter.

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[62] S.A. Gregory, "A More Detailed View of Design," in Ibid., 79.
[63] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Aubier: Editions Montaigne, 1958), 121.

Chapter 6 - Normalizations in Architectural Design Methods, 1958-1966

Before Brian Shackel began writing for *Design* and teaching courses on ergonomics for the Council of Industrial Design (CoID) (see Chapters Four and Five), he conducted experiments in electro-oculography. Electro-oculography is a technique for studying eye movements. Electrodes were placed on the skin about the orbits of the eyes and the varying electric potential difference of the currents originating in the electrodes when the eyes moved entered a vacuum tube amplifier (see Figure 6.1). The amplified electric potential difference was then recorded through an ink-writing oscillograph. This generated a record known as an electro-oculogram.[1] Like the first transistor computer in the UK, the AEI 1010, whose housing J. Christopher Jones designed (see Chapter Four), in its use value this technique selects the difference between electric potentials for transmission of information which is then recorded.[2]

Although Shackel primarily investigated the design of the electro-oculograph, in the early 1960s he participated in an experiment to record the eye movements of children with cerebral palsy. This study was intended to investigate whether differences in the perceptual skill development of children with cerebral palsy could be accounted for by developmental features of the oculo-motor control system. The study was to use "the simplest convenient technique for obtaining objective records from as many children as possible."[3] This study used an electro-oculograph to measure saccades - "the brief, rapid movement of the eye from one position of rest to another, such as in

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[1] Elwin Marg, "Development of Electro-Oculography: Standing Potential of the Eye in Registration of Eye Movement," *A.M.A. Archives of Opthalmology* 45 (February 1951): 169-185.

[2] Freidrich Kittler, "There is No Software," *Literature, Media, Information Systems* (Amsterdam: Overseas Publishers Association, 1997), 112.

[3] B. Shackel, J. R. Davis and M. L. J Abercrombie, "Electrooculography in a Pilot Study of Cerebral Palsied Children," *IRE Transactions on Bio-Medical Electronics* 9 (1962 Apr, 1962), 113.

reading"[4] - by having the experimental subject look at a large white card containing several black dots and asking him or her to focus successively on each dot from left to right in turn. The experiment also measured the eyes' ability to resist wavering from pursuit of a moving trajectory. To quantify the records, the average number of saccades per line of dots read and the average number of saccadic movements during each pursuit task was chosen. The data of "normal good" performance, derived from the sample of "'normal' children" was offered against "poor" performance.[5] In electro-oculography, difference is measured in terms of discrete signals. Discrete differences permitted a measure of normalcy as a measure of discrete deviation from a statistical average. In the concept of average, the testers found an "objective" equivalent of the concept of normal.

Shackel conducted this experiment with two others: a fellow employee of E.M.I. Electronics' Psychological Research Laboratory, J.R. Davis, and Jane Abercrombie, a biologist.

In the early 1960s, Abercrombie was chosen to lead the psychological testing of prospective architectural students at Bartlett, the School of Architecture of University College, London. Like the children in the above electro-oculograph experiments, prospective architecture students were measured relative to their conformity to a norm of normalcy as statistical average.

Furthermore, these testing procedures at the Bartlett were begun simultaneous with the introduction of systematic design methods in studios. Here again enter norms of normalcy. I take as cases: design at the Royal College of Art under industrial designer L. Bruce Archer, architectural students at the Bartlett and the University of Manchester and architects and architectural students at a 1966 conference at the Hochshule für Gestaltung (HfG) in Ulm, Germany. I argue that designs, architectural students, and architects, respectively, were viewed as equilibrating around an assumed

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[4] OED, online edition.

[5] B. Shackel, J. R. Davis and M. L. J Abercrombie, "Electrooculography in a Pilot Study of Cerebral Palsied Children," 114.

measurable norm of statistical average for which deviations from this norm of average were constructed as abnormal irregularities.

Moreover, systematic methods in the 1960s UK architectural circles also offered an ideal of designers as information processors. In this norm, designers were viewed as intuitive statisticians. The norms of design and the designer as statistician are entwined, for with the designer as statistician comes the normative view of probability theory. The normative view of probability is a view of rationality codified in mathematics. Error is miscalculation from a singular design ideal, and all design decisions then must be made on the basis of probabilities which equate the abnormal as quantitatively different from the normal. The inseparability of the role of probability in information theory cannot be discounted in the construction of the norm of normalcy as statistical average and the designer as information processor.

Thus the question is also, inseparably, what was the normative condition which activated the occurrence of systematic design methods when they were instated and why did this normative condition not exist at another time? [6] Institutionally, the interest in design methods was aided by concerns with the provision of services for peripheral populations. Richard Llewellyn-Davies developed his research methods while Director of Architectural Studies at the Nuffield Provincial Hospitals Trust (NPHT). L. Bruce Archer's systematic design methods developed at the Royal College of Art had its sole financial support from the NPHT. The UK Department of Education and Science,

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[6] As Lily Kay has noted, there was "a new space of representation-the information discourse-which emerged in the 1940s in the United States and Europe," a discourse that "would reconfigure representations of life and society as systems of decisions and signals."Lily Kay, "From logical neurons to poetic embodiments of mind: Warren S. McCulloch's project in neuroscience." *Science in Context 14* (2001): 591–614, 593. James Cutting has argued that the ubiquity of information was animated by its translatability between physical and mental events, bolstered by its use in computer science and Artificial Intelligence James E. Cutting, "Information from the world around us." In J. Hochberg, ed. *Perception and cognition at century's end: History, philosophy and theory*, (San Diego, CA: Academic Press, 1998), 69-93.

the Royal Institute of British Architects (RIBA) and the York Institute of Advanced Architectural Studies sponsored the 1966 teaching seminar at the HfG in Ulm to develop educational methods for architecture schools in the former UK African colonial states.

Hospital Design, Research Methods, and Richard Llewellyn-Davies

To practice under the title of architect in Great Britain in the 1950s, one had to attend a school approved by the Royal Institute of British Architects (RIBA) or take RIBA examinations, so RIBA approval was central for a school of architecture. At that time the Bartlett offered a full-time, five-year course in architecture with exams recognized by the RIBA. Its courses were subject to approval by RIBA Visiting Boards.

However, in 1958 the Bartlett was in crisis. The RIBA Visiting Board reported that Bartlett teaching insufficiently addressed the study of materials, building services or science. Its history courses were chastised for containing little reference to 20th century architecture. Its studio work was accused of being "uninspired and dull," heavily biased in favor of outdated building methods: its "working drawing dealt too often with methods of construction rarely in use."[7] Armed with this report, the Visiting Board threatened to withdraw Bartlett's RIBA approval.[8]

A solution was found by suggesting that a Professor designate to "overhaul the whole curriculum" be appointed to succeed the retiring Hector Corfiato.[9] The architect Richard Llewellyn-Davies was soon appointed to this position for the1960-61 year. Llewellyn-Davies was by then an architect well known for his postwar work on modular school systems, and more recently as Director

[7] M.L.J. Abercrombie and Susan Hunt, *1960-1970: Ten Years of Development in a School of Architecture* (London: M.L.J. Abercrombie and S.M. Hunt), 5/26-5/27.
[8] Mark Crinson and Jules Lubbock, *Architecture - Art or Profession?:Tthree Hundred Years of Architectural Education in Britain* (Manchester, UK: Manchester University Press, 1994), 136.
[9] Quoted in Ibid.,136

of Architectural Studies at the Nuffield Provincial Hospitals Trust (NPHT).[10]

The NPHT was but one of William Richard Morris, Lord Nuffield's charitable bodies. Having made his fortune from Morris Motors, medical causes were major beneficiaries-variously attributed to his unfulfilled desire to be a surgeon, his hypochondria, and the need to ensure the good health of his workforce.[11] Founded in 1938, ten years prior to the National Health Service (NHS), the official purpose of the NPHT was "the co-ordination on a regional basis of hospital and ancillary medical services throughout the Provinces."[12] After the creation of the NHS, the NPHT realigned itself in 1949 towards health center and hospital design under Llewellyn-Davies. Amongst its collaborators were the Department of Scientific and Industrial Research's Building Research Station and the Division of Hospital Services, US Department of Health, Education and Welfare.[13]

Llewellyn-Davies led a multi-disciplinary team whose methods embraced the reconsideration of hospital design from first principles. A team, including a physician, nurse, fieldwork organizer, historian, accountant, architect and operations researcher and aided by 39 time-study engineers, architects and assistant researchers, utilized the latest questionnaires, time and motion studies, research into the physiology of color, lighting and noise to investigate the effects of hospital construction on nursing administration, medical practices and their financial implications.

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[10] Stuart Maclure, *Educational Development and School Building Aspects of Public Policy, 1945-73* (Burnt Mill, Harlow, Essex: Longman, 1984); Andrew Saint, *Towards a Social Architecture: The Role of School-Building in Post-War England*, (New Haven, CT: Yale University Press, 1987); Nuffield Provincial Hospital Trust, *Studies in the Function and Design of Hospitals* (London, Oxford University Press, 1955); Jonathan Hughes, "The 'Matchbox on a Muffin': The Design of Hospitals in the Early NHS Medical History," *Medical History* 44 (2000): 21-56.

[11] Gordon McLachlan, *A History of the Nuffield Provincial Hospitals Trust 1940-1990* (London: Nuffield Provincial Hospitals Trust, 1992).

[12] Nuffield Provincial Hospital Trust, *A Report on the Activities of the Trust, 1939-1948* (Oxford: Oxford University Press, 1949), 9.

[13] Nuffield Provincial Hospitals Trust, *Studies in the Function and Design of Hospitals* (London: Oxford University Press, 1955).

A definitive model for the organization of research at Llewellyn-Davies's NPHT was the Medical Research Council (MRC).[14] At the MRC (of which Kenneth Craik's Applied Psychology Unit was a subdivision; see Chapter Four), wartime and postwar collaboration between psychologist, physiologists and engineers occurred in the design of the remote control of Army vehicles, human-machine interface with letter sorting machines at the Post Office (see Figure 6.2), as well as collaboration in research at British Telcom and British Rail.[15] The MRC's National Institute for Medical Research (NIMR) was established in 1913, but post WWII the NIMR revamped itself to have a flexible internal organization focused on collaboration between disciplines. A series of small units held staff grouped as needed: divisions changed their designations depending on the research currently undertaken. For example, in the 1960s two such clustered departments were Human Biomechanics and Parasitology.[16]

From hospital research Llewellyn-Davies took that:

> One of the most important things we learned in the five years of studying hospitals is the need to break down problems of aspects that can be studied objectively.... We therefore set to work to break down the problem of design into a number of separate issues, susceptible to closer study.[17]

Llewellyn-Davies believed that objectivity through quantification in research was the central hinge for improving architectural education. He phrased his sentiments in a paper given at the 1958 Oxford Conference. This Oxford Conference was an essential meeting for extinguishing the last vestiges of

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[14] Llewellyn-Davies, "Future of Research," *RIBA Journal* s3, no. v71 (April, 1964), 151.

[15] L.A. Reynolds and E.M. Tansey, eds, *The MRC Applied Psychology Unit : the transcript of a Witness Seminar held at the Wellcome Institute for the History of Medicine, London, on 12 June 2001. Wellcome witnesses to twentieth century medicine, v. 16* (London : Wellcome Trust Centre for the History of Medicine at the University College of London, 2003), 33-37.

[16] A separate department of Statistics had been abolished by the late 1930s due to its ubiquity in all subfields of medicine. Ibid, 121-123

[17] Richard Llewellyn-Davies, "Study in Hospital Function and Design," *Architectural Forum* 101 (December, 1954): 146.

Beaux Arts sympathy at the RIBA.[18] Llewellyn-Davies asserted that architectural training was to incorporate "the scientific description of the physical environment as a branch of architectural knowledge.... It is increasingly giving us the means to measure, and discuss quantitatively, aspects of design which formerly lay entirely in the subjective field."[19] This objectivity was to take specific material form:

> New, scientific knowledge is not an addition to our total stock; it is a replacement. It replaces the old rule-of-thumb principles of building construction, derived from trial and error and accumulated experience. Once we have accepted this we shall be better able to absorb the new knowledge, which implies the substitution of card-indexes and scientific abstracts for the craftman's know-how.[20]

Note cards and scientific papers, or the punch cards of mainframes, were the material memory storage of the late 1950s scientist. They are pivotal to a switch from craft-based design to scientific, quantifiable and objective research.

Furthermore, in this rush for quantification, the NPHT's 1955 *Studies in the Function and Design of Hospitals* asserted that many concerns could only be addressed through the use of statistical techniques. [21] Surveys required vast collections of data concerning all who had received inpatient or outpatient general hospital care. From hospital records for each month of 1954, all inpatient admissions and discharges were recorded by specialty; the lengths of stay and the monthly change in waiting lists was tabulated. A formula was devised for calculating the average waiting-time in terms

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[18] Leslie Martin, "Conference on Architectural Education," *Royal Institute of British Architects Journal* 65 (June 1958): 279-82; Mark Crinson and Jules Lubbock. *Architecture - Art or Profession?*, Chapter 3.
[19] Richard Llewellyn-Davies, "Study in Hospital Function and Design,"188.
[20] Richard Llewellyn-Davies, "Deeper Knowledge; Better Design," *Architectural Record* 121 (April, 1957): 188.
[21] "The Investigation came to the conclusion that it could make a contribution towards solving the problem of planning to meet demand if it analysed in appropriate detail the whole recorded load of cases dealt with during a complete year by one hospital group serving a clearly defined population of ascertainable size. It was thought important that the group should be without serious rivals in serving the population, and that the community and the component hospitals should be accounted 'ordinary' from both the social and medical points of view."Nuffield Provincial Hospital Trust, *Studies in the Function and Design of Hospitals*, 151.

of beds available, the average demand, and the average length of stay, which made it possible to predict the consequence of the supply being insufficient to fit the demand.[22] The average was deemed the measure for appropriate action.

Jane Abercrombie and Norms of Information

While conducting experiments in electro-oculography, and prior to being recruited by Llewellyn-Davies to lead psychological testing at the Bartlett, Abercrombie taught medical students at University College, London. In that context she developed a pedagogic method based on teaching as form of group therapy. Like Freud, therapy is to make the unconscious conscious: "the task which the psycho-analytic method tries to perform ...consists in making the unconscious accessible to consciousness, which is done by overcoming resistances."[23]

Furthermore, Freud attributes the difference between health and illness as quantitative: "Health and sickness are not qualitatively different from each other but only determined gradually separated in an empirically determined way."[24] However, Abercrombie establishes a quantitative nature to thought: "Free group discussion...helps you to look at...weighted averages of past experience which you have been using unconsciously and see whether they ought to be modified."[25] Freud thought of therapy in terms of the analog information mediums of his day, telephony and radio. As Kittler describes:

> Freud's materialism reasoned only so far as the information machines of his era - no more, no less. Rather than continuing to dream of the Spirit as origin, he described a "psychic apparatus" (Freud's wonderful word choice) that implemented all available

[22] Ibid.
[23] Sigmund Freud, "Freud's Psycho-Analytic Method," 1904, Trans. J Bernays, in *Collected Papers*, Vol. 1, (London: Hogarth Press, 1956), 269.
[24] Ibid.
[25] Abercrombie, M. L. J., "BASA Sheffield Conference Report 3." *Architects' Journal* (1962 Apr. 18, 1962): 829.

> transmission and storage media, in other words, an apparatus just short of the technical medium of universal-calculation, or the computer.
>
> The transmission medium in psychoanalytic treatment was a telephony which transformed sound or the patient's unconsciousinto electricity or conscious speech so that the unconscious could be transmitted, and then, through the synchronized vibrations of the attentive analyst, could be transformed back again into sound or the unconscious. These are almost Freud's precise words. What he does not reveal, however, is that at Berggasse 19 in Vienna the telephone cable had (in 1895) only been laid in the family's living quarters and not in the consultation room, so that therapy as telephony was a wireless system, or more specifically, radio *avant la lettre.*[26]

Abercrombie, in keeping that technological conditions making possible what can become a discourse, considers the brain as computer. In 1962 she elaborated to the British Architectural Student's Association

> The analogy of the human brain with the computing machine as a fashionable and very useful one... Not only is [the human brain] assembled by unskilled labor, but it is mostly used by unskilled labor, in the sense that we do not deliberately monitor our mental processes: you go on more or less unconsciously, often very well, but often inefficiently. [27]

As unskilled labor, it is the brain's use value which enters quantitatively.

It is norms of normal that Abercrombie offers to group therapy or what she terms "free group discussion" among her medical students. She initiated an exercise with the students to discuss conceptions of normality, drawn from an excerpt of a medical journal which used the term "normal" without providing an obvious definition of its meaning.[28] The students were asked to discuss their understanding of its intended definition. Her goal was to improve their awareness of factors influencing their judgment, "that the receipt of information from words involves [a] processes of selection and interpretation...; and that some understanding of the factors affecting these processes

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[26] Friedrich A. Kittler, "The World of the Symbolic - A World of the Machine," in *Literature, Media, Information Systems* (Amsterdam: OPA, 1997), 134.
[27] Abercrombie, M. L. J., "BASA Sheffield Conference Report 3," 829.
[28] M.L.J. Abercrombie, *The Anatomy of Judgment; an Investigation into the Processes of Perception and Reasoning* (New York: Basic Books, 1960), ch.7.

might help them to use language with greater effectiveness."[29] She exposes the distinction between descriptive and prescriptive normality: The statistical model of normal as average converts observations to a context dependent summary of data points; the cultural concept of normality is prescriptive and entails standards of conduct and belief, deviance from which is deemed bad or mad. She reports that 47% of students think of normal as statistical average.[30]

A normative position always conditions the norm of the normal. It becomes clear that she considers the normal as statistical average and sees the abnormal as typified in the mentally ill.

> A lunatic can be said to be normal or like the majority in a mental hospital, but not normal or like the majority outside it, i.e., he is being referred to two different populations, and is normal or not normal according to the population...Confusion arises because though he may be normal...within the mental home population he is not normal in [the] sense [of] healthy.[31] .

Abercrombie provides a medical model of normality, for the normal is a quantitative deviation from the normal. Furthermore, one can dissect judgment as one dissects biology: "by dissecting examples of making judgments in the class-room."[32] This stance takes judgment on analogy to biological objects. Mental illness is viewed as an abnormality which is measurably different from a normal state. This medical model of normality uses rules to evaluate behavior that are presumed to reflect real, quantitative, differences between health and sickness.

Abercrombie further stresses the centrality of information processing.

> All day and every day we are receiving information through our sense organs...Our efficiency in living our lives as ordinary human beings depends on what we do with this bombardment of information: what we ignore in it, what guidance to immediate action we accept from it, how we store it and how we use the store....We are

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[29] Ibid., 109.
[30] Ibid., 99.
[31] Ibid., 111.
[32] Ibid., 18.

> continually selecting from the information presented, interpreting it with information received in the past, and making predictions about the future.[33]

The appropriate probabilistic weighting of information permits appropriate selection, storage and processing. The hinge to health is the organization of information. According the Abercrombie, "the mentally sick are those whose store of information is inappropriately organized; their schemata or assumptions are such that the information they receive from the environment, both physical and social, does not lead to effective action."[34]

Disorders and illnesses were understood as arising from disruptions in the way in which the organism dealt with information. Since Norbert Wiener, the view of communication as depending on the transmission of information became elemental in understanding order (see Chapter Three). Wiener discussed movement disorders and concluded they resulted from an inappropriate transmission of information.[35] Warren McCulloch commented that his work with Walter Pitts allowed descriptions of neuroses wholly dependent upon the order of information transmission.[36] Such accounts encouraged the idea that information gave the organism order. This view was wholly consistent with Claude Shannon's explanation of the relationship between information and entropy. Entropy in information theory is a measure of the average information rate of a message.

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[33] Ibid., 13-14.

[34] Ibid., 61.

[35] Norbert Wiener, *Cybernetics*; or, *Control and Communication in the Animal and the Machine* (Cambridge, MA: Technology Press, 1948).

[36] Warren McCulloch, "Mechanisms for the spread of epileptic activation of the brain," *Electroencephalography and Clinical Neurophysiology 1* (1949): 19–24; Lily Kay, "From logical neurons to poetic embodiments of mind: Warren S. McCulloch's project in neuroscience." *Science in Context 14* (2001): 591–614; N. Katherine Hayles, "Boundary Disputes: Homeostasis, Reflexivity, and the Foundations of Cybernetics," *Configurations* 2, no. 3 (1994): 441-467.

Psychological Testing at Bartlett

The project of mental testing at the Bartlett was funded by the Leverhulme Trust, a foundation supporting education and research established with shares of Lever Brothers, bequeathed by soap magnate William Hesketh Lever. Llewellyn-Davies's proposal to the Leverhulme asserted that far too many students who "entered architecture" were unsuited to the field, regardless of how "trained".[37] This argument, together with the realization that "architects were handling in the course of a year as much as £1,000,000,000 of the country's capital resources," inspired the Trust to provide financial support of psychological testing for five years.[38] Starting in 1964, prospective students were administered a series of tests when interviewed for admission, intended to assess "general intelligence, spatial ability and personality."[39] A battery of 16 tests in total was administered over five years. Using paper and pencil examinations, scored on an IBM System 360 (see Figure 6.3), 16 theories of the human psyche were exchanged, tabulated, compared, and correlated.

Note that the psychological testing of British students was nothing new in the 1960s. Around 1930, the UK instated the mass mental testing of "normal" school-aged children.[40] The British educationist Robin Pedley wrote in 1963 that "the outlook of most professional educators [has] for a generation [been] under the influence of a school of educational psychologists whose prime concern was mental measurement."[41] By 1964 nearly 94% of local education authorities used

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[37] Richard Llewellyn-Davies, quoted in Leverhulme Trust and Asa Briggs, *The Story of the Leverhulme Trust: for Purposes of Research and Education* (London: The Trust, 1991), 129.
[38] Leverhulme Trust and Asa Briggs, *The story of the Leverhulme Trust*, 129.
[39] M.L.J. Abercrombie, Susan Hunter and Peter Stringer, *Selection and Academic Performance of Students*, 25.
[40] Brian Evans and Bernard Waites, *IQ and Mental Testing: an Unnatural Science and its Social History* (Atlantic Highlands, NJ: Humanities Press, 1981), 86; Gillian Sutherland, "The Magic of Measurement: Mental Testing and English Education 1900-40," *Transactions of the Royal Historical Society* 27 (1977): 140.
[41] Robin Pedley, *The Comprehensive School* (Baltimore: Penguin Books, 1963), 43.

standardized intelligence tests for secondary school selection in England and Wales.[42] More significantly, since Alfred Binet and Theodore Simon were asked in 1904 by the Paris Ministry of Public Instruction to devise an intelligence scale to determine whether students were "normal or retarded," intelligence testing has been used to normalize specific groups while simultaneously isolating, labeling and proscribing other populations.[43] Why did architecture choose, relatively late in the game, to adopt such examinations? What is significant here is both the shift from intelligence tests exclusively, to include personality tests, and the data processing apparatuses which accompanied this shift.

Many of the tests administered at Bartlett based on those developed by L.L. Thurstone, a psychologist at the University of Chicago. He sought to identify aspects of the mind which could be traced to definite causes. Railing against the psychologist Charles Spearman's "g," or single number of general intelligence as a unitary quality underlying all cognitive activity, Thurstone wrote: "we cannot be interested in a general factor which is only the average of any random collection of tests."[44] Rather, he advocated the use of *factor analysis.* Calling his major work *The Vectors of Mind,* he wrote "It is true that the object of factor analysis is to discover the mental faculties."[45] Factor analysis is a statistical technique to summarize a large number of variables into underlying constructs, or factors.[46] Thurstone assumed that tests revealed three "real" faculties of the mind - essentially, spatial, verbal

[42] Figures from National Foundation for Educational Research in England and Wales, *Local Authority Practice in the Allocation of Pupils to Secondary Schools* (London: NFER, 1964). Quoted in Brian Evans and Bernard Waites. *IQ and mental testing,* 110.
[43] Alfred Binet and Theodore Simon, "Methodes Nouvelles pour le Diagnostic du Niveau Intellectual des Anormaux," *Annee Psychologique 11* (1905), 191-244. Quoted in Stephen Jay Gould, *The Mismeasure of Man* (New York: W.W. Norton, 1981), 152.
[44] L.L. Thurstone, "Current Issues in Factor Analysis," *Psychological Bulletin* 37 (1940): 189-236, 208.
[45] L.L. Thurstone, *The Vectors of Mind;Multiple-factor Analysis for the Isolation of Primary Traits* (Chicago: Univ. of Chicago Press, 1935), 53.
[46] See Stepher Jay Gould, *The Mismeasure of Man,* ch.6, for an illuminating lay discussion of its details.

and numerical: "The factorial methods have for their object to isolate the primary abilities by objective experimental procedures so that it may be a question of fact how many abilities are represented in a set of tasks."[47] Yet a factor is simply a weighted linear sum of the variables tested: "a factor is produced by adding in carefully determined portions of some tests and perhaps subtracting out fractions of other tests."[48] Regardless of the statistical fancy involved in scoring these tests, the abnormal is constructed as a *real* quantitative deviation from a normal statistical distribution. Similarly, Thurstone had proposed a measurement of perceived sensory qualities that assumed a normal distribution of sensory processes.[49]

Whereas Thurstone's tests were tests of intelligence, other tests administered by the Bartlett were personality tests. One in particular was the Dynamic Personality Inventory (DPI), devised by Tadeusz Grygier, a psychologist at the UK government sponsored National Foundation for Educational Research. The DPI is a psychoanalytic test with 325 items, for which the test taker marks his or her reaction in terms of "like" or "dislike." It contains 33 scales to test for psychosexual development, agglomerated into 5 groups. As Abercrombie explained it:

> The 'oral' (in non-psychoanalytic terminology this would be 'outgoing emotionality and self-assertion') and 'anal' (obsessiveness and authoritarianism), 'phallic' (sensuality, imagination and ambition), 'mature social interests' (identification with the roles of one's own sex, tendency to participate in social activities) and 'ego strength' (persistence and initiative).[50]

The test's norm is a normalized single number score for each of the 33 scales. Without normalizing the data, there is no comparability of measurement. It is not the data itself, the group

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[47] L.L. Thurstone, *Primary Mental Abilities* (Chicago: University of Chicago Press, 1938), 1.
[48] Robert J. Gregory, *Psychological Testing: History, Principles, and Applications* (Boston: Allyn and Bacon, 1992) 290.
[49] Gerd Gigerenzer *The Empire of Chance: How Probability Changed Science and Everyday Life* (New York: Cambridge University Press, 1989), 205.
[50] M.L.J. Abercrombie, Susan Hunter and Peter Stringer, *Selection and Academic Performance of Students in a University School of Architecture*, 49.

averages, that are to be explained, but their deviation from the normative answer.[51] Statistics count as evidence, considered capable of proving and disproving theories, representing more or less interesting results. Despite statistics being theory laden and often open to re-interpretation, statistics count as self-sufficient results. In discussing measurement in general, the historian of science Karin Knorr Cetina writes "They are granted a powerful role in validating knowledge, and they are considered irreplaceable as witnesses and arbiters of scientific disputes. They provide, one might say, end-of-the-line verdicts."[52]

The language of the psychoanalytic psychological test entered into the very language used to discuss the candidates. The testing technology altered the discourse:

> If our candidates were selected on previous academic record alone, it would seem that those offered places would, on the average, not differ markedly from those rejected, as far as their personalities as assessed by this test are concerned. But if selection were made according to our ratings on either the Referee's report, or the Candidate's Statement, or on a combination of these, then there would be significant differences on various personality scales....It does seem that several characteristics - initiative', 'emotional independence', and lack of 'passivitiy' - to which interviewers respond favorably, tend to be associated with good performance at this point. These results are particularly encouraging, because if the DPI scales are valid in our context, these characteristics are certainly among those which the Bartlett would wish to see associated with success in examinations and studio work.[53]

The language of the testing altered the way students were constituted as students. This is a medical model of the mental, as the student who fails to finish on time is referred to as "limping."[54] It treats the mentally abnormal along the lines of a bodily illness. This normativity is predicated on an image

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[51] Gerd Gigerenzer, *The Empire of Chance*, 227.
[52] Karin Cetina Knorr, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999), 53.
[53] Ibid, 131-132.
[54] M.L.J. Abercrombie, Susan Hunter and Peter Stringer, *Selection and Academic Performance of Students in a University School of Architecture*, 78.

of model man.[55] This conceptualization of normal is a norm which imposes requirement on existence. Persons, and society, are thought to equilibrate around an assumed norm and any deviation from this standard is considered indicative of illness.

The last test to be considered that was administered at Bartlett was a personality examination titled the California Psychological Inventory (CPI). This was developed by the psychologist Harrison Gough, who began his career conducting personality tests for the US military.[56] Yet, to examine the CPI is, in a sense, not essential. What is essential is to examine the schedule of which the CPI is but an imitation, from which it borrowed a number of questions and without which it would not have existed - the Minnesota Multiphasic Personality Inventory (MMPI). The MMPI, as its inventors, psychiatrist J.C. McKinley and psychologist Starke Hathaway described it, is "a psychometric instrument designed ultimately to provide, in a single test, scores on all the more important phases of personality."[57]

McKinley and Hathaway selected as a group of subjects, one group of 724 "normals" (Minnesotans, white, nearly all protestant and of Scandinavian descent) who had never been hospitalized and another group of psychiatric patients. McKinley and Hathaway also selected a collection of symptoms. Symptoms were assigned to the subject being examined by determining which questions distinguished the "normals" from the psychiatric patients. The answer given by the "normals" became the normal answer; the answer given, for example, by the diagnosed depressives became a sign of depression. Those questions that best discriminated between normal and psychiatric

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[55] Michel Foucault, *Abnormal: Lectures at the Colláege de France, 1974-1975*, Valerio Marchetti and Antonella Salomoni, eds. Trans. Graham Burchell (New York: Picador, 2003).
[56] Harrison G. Gough, "Simulated Patterns on the Minnesota Multiphasic Personality Inventory," *Journal of Abnormal & Social Psychology* 42, no. 2, (April 1947): 215-225.
[57] Starke R. Hathaway and J. C. McKinley. *The Minnesota Multiphasic Personality Inventory*. (Minneapolis: University of Minnesota Press, 1943), 2.

patients were included in the questionnaire. High scores were associated with hypochondriasis, depression, hysteria, psychopathic deviate, paranoia, psychasthenia, schizophrenia, and hypomania.[58] In 1946, a medical journal reported the MMPI "is used routinely by hundreds of private clinics and individual doctors; it is part of the personnel procedure in some of our largest corporations; it was used by individual medical and psychological personnel in all theaters of war...[and] it is used today in all veterans' administration medical clinics."[59]

If the MMPI permitted personality disorders to be efficiently and automatically partitioned, tests such as the CPI permitted businesses and educators to identify and compartmentalize gradations of "normal" personality.[60] This was not a question of madness or sanity but a question of a graded scale of abnormalities. With the CPI, Gough proposed a structural model of personality such that there are 480 questions from which 20 factors constitute a profile of personality. Like the MMPI, answers to questions such as "sometimes I think of things too bad to talk about" or "I have never been in trouble with the law" were given in terms of "true," "false," or "cannot say." One score was intended to measure a person's "sense of well-being." Those with low scores were deemed "unambitious, leisurely, awkward, cautious, apathetic, and conventional; as being self defensive and apologetic; and as constricted in thought and action."[61] Throughout the scales, low scores were associated with negative traits and poor intelligence. There is no necessity to this, no statistical requirement, yet just as in an IQ scale or a pay scale, higher scores are positive.

Before leaving these tests it is important to understand their scoring procedures. It is important because it embodies the organization of information, the separation and

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[58] Ibid., 7-16

[59] J. Arthur Myers, "Jon Charnley McKinley," *The Journal-Lancet* (November 1946): 238-241.

[60] Harrison G. Gough, *Manual for the CPI, California psychological inventory* (Palo Alto, CA: Consulting Psychologists Press, 1960), 7.

[61] Ibid., 12.

compartmentalization of selection, storage and processing, which made possible the allocations to card-indexes and scientific abstracts Llewellyn-Davies saw as the future of architectural research. Consider instructions Gough provides for the machine scoring of the CPI on the IBM 805 Test Scoring Machine (see Figure 6.4):

> Machine scoring requires 22 keys—20 used in pairs and 2 used singly, making 12 insertions of the answer sheet. Since four of the scales include items on both sides of the answer sheet, part scores are obtained on these scales and must be added after the machine runs are completed....Scoring is done with the Master Control Switch at "A." The "Rights" key is placed in the bottom leaf of the scoring frame, face down. The "Elimination" key is placed in the top leaf, face down. With the "A" switch on "R," the score appearing in the meter is the score for the scale of any given pair which is listed under "Rights" in Table 1. The switch is then moved to "W" and the score for the scale listed under "Wrongs" appears in the meter....Following scoring, the four part-scores on the back are transferred to spaces provided on the front and the necessary additions made. The scores are now ready to be copied onto the profile sheet.[62]

Personality answers are treated as right, wrong or eliminated. These instructions depict the automatic process by which one is able to turn personality into one of numerous scores. Instructions for assessment of the test results are similarly automatic and algorithmic:

> Step 1. Note the over-all profile elevation...
>
> Step 2. Note differential elevation of the four groups of scales....
>
> Step 3. List the highest and lowest scales....
>
> Step 4. Study the unique features of the profile....
>
> Step 5. Consider the internal variability of the profile.... [63]

Through this process one could assign to a test- taker numerical scores registering, for example, "responsibility," "socialization," "self-control" and "achievement via conformance."[64] Scores are to quantify "real" personality traits. As Gough writes:

[62] Harrison G. Gough, *Manual for the CPI*, 8-9.
[63] Ibid., 15.

> In a real sense, any issue whatsoever which involves interpersonal or social-interactional behavior is a proper research concern for the CPI; the justification for this assertion lies in the inherent aim of the instrument: to provide valid and utilitarian measures of the essential personological dimensions of the social personality.

These tests did not enter individual student's selection, but the results led to a reduction of interview weight and a recommendation to utilize solely the paper qualifications, although not the test results.[65] Indeed, "the total effect of the selection procedure was to offer places to a group of candidates who clearly differed on the tests from those rejected."[66] Numerically assessed events become currency in seeking objective validations.

Bartlett Pedagogy

Llewellyn-Davies sought to find the objective constituents of design, as the CPI sought to locate the real factors of personality. Just as the methods of approach to the process of scoring and assessing these mental tests was prescriptive and sequential, so was the process of design taught to Bartlett students. For example, the year following the first use of psychological tests at Bartlett, 1965, third year students' studio program for a motorway station explicitly required a phased approach:

Phase 1. Problem appraisal;

Phase 2. Solution, selection and development;

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[64] Ibid., 12-13.

[65] "It was our intention in setting up this arrangement, to collect information which could be used to evaluate the various criteria, and especially to ascertain whether the immensely costly interview was justified." P. 37 " At present it looks as though the great expense of interviewing, at least of triple interviewing, is not justified...We think it likely that candidates can be selected quite effectively on the basis of paper qualifications," 132, M.L.J. Abercrombie, Susan Hunter and Peter Stringer, *Selection and Academic Performance of Students in a University School of Architecture.*

[66] Ibid, 130.

Phase 3. Detailed development and communication.[67]

In studio, much of the time for fourth year students was spent on "operational systems," achieved in four stages: Familiarization with problems; Design and development; Detailed construction design; Manufacture.[68] These stages are significant because both the process of designing and the processes of grading and assessing a psychological test occur in explicit stages, with the use of these stages to provide objectivity. Just as these psychological tests were intended to find the real, objective factors of personality, the pedagogy of design was to provide objectively correct design answers. This discussion does not explain the origin of the staged design approach, but shows the permeation of explicitly circumscribed actions.

Interest in stages of design was embedded within a specific concern with what Bartlett pedagogy termed "communication." By 1964, lecture and studio courses focused primarily on "communication": there was a course in "perception and communication" and another course, "aspects of biological science", was devoted to "communication in animals and men."[69] In 1965, students attended an "information workshop (communications course)" and lectures on "information, classification, storage and retrieval."[70]

Simultaneously, lectures focused on a procedural "Design Method."[71] What is this connection between communication and the procedural, staged approach? To turn to a technohistorical question, to that which addresses both stages and communication, it is necessary to consider information theory. In 1948, the American engineer Claude Shannon proposed his "Mathematical Theory of

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[67]M.L.J. Abercrombie and Susan Hunt, *1960-1970: Ten Years of Development in a School of Architecture*, Appendix C, 7.
[68] Ibid., Appendix D, 4.
[69] Ibid., Appendix C, 1.
[70] Ibid.
[71] Ibid., Appendix D, 2.

Communication." It hinged upon a five-fold division of the sequence of a communication path. In Shannon's words (see Figure 6.5):

> 1. The *information source* ...produces a message or sequence of messages to be communicated to the receiving terminal.
>
> 2. The *transmitter*...operates on [or encodes] the message in some way to produce a signal suitable for transmission over the channel.
>
> 3. The *channel* is merely the medium used to transmit the signal from transmitter to receiver.
>
> 4. The *receiver*... performs the inverse operation of that done by the transmitter, reconstructing [or decoding] the message from the signal.
>
> 5. The *destination* is the person or thing for whom the message is intended.[72]

Further popularized by statesman of science Warren Weaver in the US, Shannon's theory also spread throughout British psychology in the 1950s. At the Applied Psychology Unit (APU) of the British government's Medical Research Council, the psychologist Donald Broadbent proposed that the concepts of information theory were suitable to describe an organism that selects incoming information by means of "sensory channels," stores and processes that information.[73] The APU psychologist W.E. Hick determined that in making choices consequent to signals, humans gain information at the rate proposed by Shannon's information theory.[74] In its pop art manifestations, information theory was evident as a way to rethink artistic collaboration at the 1956 show of the

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[72] Claude Elwood Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana, IL: University of Illinois Press, 1949), 33-34.
[73] Donald E. Broadbent, *Perception and Communication* (New York: Pergamon Press, 1958).
[74] A. L. Thomson, *Half a Century of Medical Research: Origins and Policy of the Medical Research Council,* Two Vols. (London: Medical Research Council, 1973–1975), vol. 1, 133–146, vol.2, 172-175; L. A. Reynolds and E. M. Tansey, eds. "The MRC Applied Psychology Unit,"in *Wellcome Witnesses to Twentieth Century Medicine,* Vol. 16. (London: The Wellcome Trust Centre for the History of Medicine at University College London, 2003).

Independent Group, *This Is Tomorrow*, at the Institute of Contemporary Arts in London (see Figure 6.6).[75]

Consider now the design method proposed by Gordon Best, one of Bartlett's teachers after Llewellyn-Davies overhauled the Bartlett pedagogy. In 1967-68, Best taught "working method" to 3-5th year design course students.[76] Best proposed that designing is wholly information selection, storage and processing (see Figure 6.7):

> 1. *Inputs* represent the input of external information.
>
> 2. *Encoder* represents the coding of internal and external information with respect to the particular design problem.
>
> 3. *Process* represents the designer's mind, which contains
>
>   3a. an *Information Store*
>
>   3b. *Processes*, which "stands for the operations a designer goes through when responding to the input information and weighing this up against the information supplied by his memory. It is here that he decides, predicts, hypothesises and mentally copes with his problem."
>
> 4. *Decoder* represents the transformation of internal to external information
>
> 5. *Outputs* represent the design information produced
>
> 6. *Control* represents cultural and theoretical constraints on designs, "limiting the way in which information can flow."[77]

This depiction of design operates like a computer (information store, process and control) hybrid with a mathematical theoretic communication system (information source or input, transmitter or encoder,

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[75] Anne Massey, *The Independent Group: Modernism and Mass culture in Britain, 1945-59* (Manchester, UK: Manchester University Press, 1995); David Robbins, *The Independent Group: Postwar Britain and the Aesthetics of Plenty* (Cambridge, MA: MIT Press , 1990).
[76] M.L.J. Abercrombie and Susan Hunt, *1960-1970: Ten Years of Development in a School of Architecture*, Appendix C,10.
[77] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture, Architectural Association Paper Number 4*, (London: Lund Humphries, 1969), 152.

receiver or decoder, destination or output). For Shannon, noise is a perturbation in the communications channel such that the received signal is altered from the transmitted signal. In Best's model, the designer becomes the communications channel, a medium for which there is no mention of noise, no concern for disturbance, interruption, or deviation.

Abercrombie also taught several of the courses which focused on communication.[78] What is of significance is that, just as with the psychological testing, technological regulation replaced pedagogic norms. Pedagogy was employed to construct student thought in the same manner as computers process information, in explicit stages.

University of Manchester: Testing and Pedagogy

The Bartlett was hardly the sole architecture school to embrace a staged design methods for architectural studio teaching. In 1958, D.G. Thornley instated the first staged design method in architectural studio work in the UK, at the University of Manchester School of Architecture. Presenting it at the 1962 conference organized by J. Christopher Jones and Peter Slann, he offered the 1958 process as:

1. The Accumulation of Data;
2. The Isolation of a General Concept of "Form";
3. The Development of the "Form" into the Final Scheme;
4. Presentation.[79]

By1964, he had altered the process slightly:

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[78] M.L.J. Abercrombie and Susan Hunt, *1960-1970: Ten Years of Development in a School of Architecture,* Appendix C, 1.
[79] {{237 /s47}}

1. Accumulation of Data

2. Exploration of the Problem and Possible Solutions

3. Development and Refinement

4a. Working Drawings

4b. Presentation

with "feedback" operating between the first three stages.[80]

The procedural approach is a view towards the normal of designing: "Many Architects would, however, maintain that they follow the sequence of the "method" fairly closely and that it merely represents a clear statement of what normally takes place."[81] The norms of the procedural representations are to capture the normal form of design. The norm is to be understood within a project of normalization. The method he pioneered would become the basis for the codified staged procedure in RIBA's 1963 *Handbook of Architectural Practice and Management.*[82]

At Manchester the procedural process was taught in second year studio from 1958 until the late 1960s.[83] As with the Bartlett, a staged procedure was conducted along with psychological testing of students. At Manchester these tests were administered to current second year students in hopes that they could be used ultimately for admission procedures. The tests were to assess specific mental capacities operative at each stage of the design process they were then teaching in studio.[84]

These tests were based on work by American psychologist J.P. Guilford. Guilford proposed

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[80] "Learning to Design: Leeds Conference Report," *Architects' Journal* 140, no. 16 (October 14, 1964), 849.
[81] J. Christopher Jones and D. G. Thornley, *Conference on Design Methods,* 44.
[82] Geoffrey Broadbent, "Design Method in Architecture," *Architects' Journal* 144, no. 11 (Sept, 1966), 679-685.; Royal Institute of British Architects, Handbook of Architectural Practice and Management, vol.3, 1963
[83] D. Buttle et al., "Framework for Design Learning," *The Builder* (11 February 1966): 279-282.
[84] D. Buttle, J. Freeman, and J.G. McComisky, "The Measurement of Ability in Architecture," *The Builder* (September 10, 1965): 537-539.

what he termed the "structure of intellect" model (see Figure 6.8).[85] Like Gough, Guilford advocated a factorial analysis of personality - a search for the real factors of personalities. "Operation," "product" and "content" make up its main categories, together with 16 sub-classifications. However, thinking, for Guilford, was solely the province of the "operation" category. This category held, in order: memory; cognition; divergent production; convergent production; evaluation. Divergent production, Guilford asserted, is responsible for creative thinking. It is "generation of information from given information, where the emphasis is upon variety and quantity of output from the same source"[86]

Guilford equates the ideal system of information processing - the computer - with the functioning of human thought.

> Many parallels between the workings of a computer, what it does and how, and the behavior of a human organism are rather obvious...processes of receiving and sorting information are the computer's operations of cognition. Memory storage is of course obviously parallel...Retrieval of information is parallel with both divergent and convergent production. Computers are programmed to apply algorithms, which are ironclad sequences of operations that can be applied in solving mathematical problems and problems of logic. This is the analogue of convergent production. Where such programs are not possible, heuristics are applied. ...Almost any strategy that has somewhat general application can be regarded as a heuristic. We may say that the use of heuristics means indulging in divergent production....Evaluation enters the computer's repertoire of basic operations in terms of matching information and of accepting or rejecting the matches in terms of criteria.[87]

Integral is the economic importance of creative thought.

> The creative person has *novel* ideas. The degree of novelty of which the person is capable, or which he habitually exhibits, is pertinent to our study. This can be tested in terms of the frequency of uncommon, yet acceptable, responses to items [emphasis original].[88]

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[85] J. P. Guilford, *The Nature of Human Intelligence* (New York: McGraw-Hill, 1967).
[86] Ibid., 213.
[87] Ibid., 342-3.
[88] J.P. Guilford, "Creativity," *American Psychologist* 5, no. 9 (Sep 1950): 452.

The delusions of a schizophrenic most certainly might be novel, yet such novel ideas are not acceptable within measures of creativity. Why? Because: "The enormous economic value of new ideas is generally recognized."[89]

The tests given at Manchester were comprised of four parts: two tested divergent production or thinking and two tested convergent production. The exam consisted of sixteen wooden blocks which differed in ten characteristics. Students were asked to first arrange the blocks according to self-selected principles. The first test required two groups of eight blocks each in four different ways; the second required the student to arrange four groups of four blocks each in four different ways. This portion was to be a test of divergent thinking. Subsequently, the two tests were repeated, only according to principles given to the students. This portion was to test convergent thinking.[90] The results concluded that the students who were best in coursework were best at these exams. Thus the tests were said to provide evidence for the "nature" of creative architectural work.[91]

The Department of Architecture at the University of Manchester said to its second year students: *Sit here, let us measure you relative to these norms, which are normalized averages that we have gathered. Let us see if these norms of education match the real factors of intelligence... They do!* Well, is that not surprising, given that the norms of education were already replaced by a technological regulation. The test is that to which a computer is perfectly suited - the arranging of finite objects in finite combinations. Here was a test that stated: indeed, intelligent students think like computers. Here was further confirmation of the real factors of intelligence since they had already assumed that students think like computers and had been educating them in this manner.

[89] Ibid., 446.
[90] D. Buttle, J. Freeman, and J.G. McComisky, "The Measurement of Ability in Architecture," 537-539.
[91] Ibid, 537.

Indeed, the design process itself was seen as a form of psychological test of design capacities.[92]

In 1964, after hearing speakers such as Gordon Pask, J. Christopher Jones and D.G. Thornley, the annual meeting of the British Architectural Student Association (BASA) "decided to pass a blanket resolution: 'BASA affirms the need for a systematic approach to design, and should foster experiments in this field to encourage the use of conscious design methods in schools. The emphasis on design programmes in schools should be shifted from the results achieved to the methods by which they were achieved.'"[93]

Conference Course at Ulm

In April 1966, a conference course on "The Teaching of Design - Design Method in Architecture" was held at the HfG.[94] Invited by HfG director Tomas Maldonado and its administrators, the conference was sponsored by the UK Department of Education and Science, the RIBA Board of Architectural Education, and the York Institute of Advanced Architectural Studies. 30 architecture instructors gathered for nearly three weeks to devise a "Programme for developing countries" in Africa, for implementation by architecture students in the former British Colonies of Ghana, Sudan, Nigeria and Kenya. The conference was to plan a program framework for students to execute 5 design stages over 5 weeks: data collection, analysis, synthesis, development, and prototype production for "market stalls, Game reserve huts, Knock-down housing, Game observ[ation] points."[95]

Jones presented his systematic design method, generalizing it for architecture without significant alteration from the method proposed for industrial design (see Chapter Four). Denis

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[92] D. Buttle et al., "Framework for Design Learning," 280.
[93] "Learning to Design: Leeds Conference Report," 849.
[94] Conference Course on "The Teaching of Design - Design Method in Architecture," *Programme, group 4*, 1966.
[95] Ibid, 6.

Hinton, Principal of Architecture at the University of Aston at Birmingham, Oxford 1958 Conference attendee and influential member of the RIBA education board,[96] had stated that procedures in architectural design teaching should be thought of as an ordered teaching sequence, based on the critical path approach of operations research. The "order of teaching" was a "series of networks with the object of establishing a critical path approach to the syllabus as a whole and to requirements of particular subjects."[97] The order of teaching superceded the course content. Thornely also discussed his staged approach.

Geoffrey Broadbent, Thornley's student, embraced viewing the designer as intuitive statistician, and designing as analogous to perceptual statistics:

> An observer experiences the built environment by means of all his senses, acting simultaneously. For each sense channel, the act of perception consists of transaction between "what is out there" and our personal predictions based on past experience. Any design process which fails to tap, at several stages, the designer's own past experience to determine what is going to be "out there" in the form of a new building, is simply failing to use to the best advantage the most efficient multi-channel predicting "machine" available to it, the human body and brain. This works like decision theory, where the designer implicitly produces a list of possibilities and predicts for each a possible outcome, and to each a degree of probability. then examined in terms of value system and assigns a degree of desirability.... The facts are fed in, the modified and distorted by our mental processes, to come out as new ideas. In this way this is analogous to what happens to the physical stimulus in the act of perceiving.[98]

He offered an approach to design contingent upon the separability of information processing-machine's use value functioning: "If we separate the parts of a design system according to the mental processes involved, we shall find that they number six."[99]

As statistics and their historical development were closely tied to mental testing, Broadbent's

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[96] Anne Corbett, "Education Year," *RIBA Journal* (April 1970), 164-166.
[97] Denys Hinton, "Educational Research," *Architects' Journal* 141, no. 26 (30 June 1965), 1515.
[98] Conference Course on "The Teaching of Design - Design Method in Architecture," 47.
[99] Ibid., 19.

view of the designer as intuitive statistician draws on the mental testing of architects. At Ulm, Broadbent reports the results of a test of architect's aptitude in terms of "personality correlates of creativity." Average scores for architect's personality traits along side those of "typical" Americans. The percentages are generated relative to a population distribution, such that the statistical average is the normalized norm. "Types of men" are divided into six categories, such as "ECONOMIC - conforming closely to the prevailing stereotype of the "average American businessman""[100] This test created a set of norms, statistically normalized. Personality traits are measured relative to the norm, and the distribution measured relative to the normal as average. Norms are naturalized as normal for which, from the average personality is measured as deviations from the normal.

The entire endeavor of personality and creativity testing was enormously supported. In the US, institutions from the Carnegie Foundation to the National Science Foundation to Dow Chemical all contributed extensive resources for the support of these inquires into creative personalities. In the UK, the contributions were on a smaller scale but specifically supported by the UK government, through the British Government's University Grants Committee's allocations. The UK government also provided financial support to the non-profit National Foundation for Education Research which actively developed student personality tests. Furthermore, this research into creative personality testing was supported through nonprofit institutions such as the Leverhulme Trust.

So what was the tangible result of this mental testing? At Manchester psycholgical tests were given to current second year students in hopes that they could be used ultimately for admission procedures, although they never were. Similarly at Bartlett, it was hoped that the psychological tests of students could be used for admissions procedures, although, again, they never were. In one regard,

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[100] Ibid., 18.

these tests were an enormous waste of time and money with little tangible result. But alternatively, these tests were a profoundly important in ushering a replacement of subjective judgments of candidates' personality with objective, scientific data. For example, when Llewellyn-Davies took office at Bartlett in 1960, four selection procedures for students were operative: an assessment of candidates' academic record, a recommendation or "referee's report," a candidate statement and an interview. Each was given a letter grade, A through E, by an assessor. The weight given criteria for selection varied during the 1960s, although initially the interviewer did not review the paper credentials. The prospective students and their coursework, once accepted, were subject to judgment according to the same scale: A through E. These pedagogic norms informed both the selection of students and their assessment once accepted. But these tests contributed to a turning away from placing weight on a personal interview towards more objective paper credentials and as such technological regulation replaced pedagogic norms.

L. Bruce Archer and the Designer as Intuitive Statistician

Research into hospital design altered design thinking in a further profound way, through the support of the systematic design method of L. Bruce Archer. Archer, trained as an industrial designer, taught at the HfG in the early 1960s. Archer subsequently taught at the Royal College of Art's Unit in Design Research under the Industrial Design (Engineering) Division, established by Misha Black.

The charity King Edward's Hospital Fund for London established a Working Party of medical professionals, which chose to sponsor the development of new designs for hospital furniture. The Fund commissioned the Unit, reporting to the Working Party, to investigate and provide the development of new hospital furniture designs. In 1961 NPHT provided the funding. Archer was appointed as director of the Unit. As Archer recalled, the project required accountability to the Working Party as well as 450 hospital management committees. It was funded at £67,090 for four-years (approximately 800,000 in 2007 USD).[101]

The research method the team proposed involved humans simulating the storage and retrieval functions a digital computer:

> 9.3 The investigation ... involves the handling of, and making decisions upon, a large and complex mass of information, and the organisation adopted must ensure that whenever a particular problem is under consideration, the relevant items are retrieved automatically, even when the investigator is not aware of their existence.
> 9.4 The system adopted must also ensure that every ongoing procedure (e.g. correspondence and items awaiting action) is automatically followed up until concluded, and that all procedures are self-checking.
> 9.5 The investigation is therefore organised on the basis of self-checking communications routines, in which every communication (letter, report, drawing, telephone call, etc.) is recorded.[102]

This system hinges upon categorizing "communications" according to four classes: "all communications bearing information" from studies of equipment or user needs ("Class A"); communications originating in the research unit ("Class B"); information devised by or confirmed by the unit while conducting research ("Class C"); and information from areas that in the future might be significant for the investigation ("Class S").[103] The goal is to reduce all information to that devised or confirmed by the unit - "Class C" - to a "symbolic logic for operating" so that design may then be a product of its manipulation.[104] The report illustrates the system through diagram of information input, output and redundancy according to this symbolic class categorization (see Figure 6.9).

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[101] Misha Black and L. Bruce Archer, *Studies in the Function and Design of Non-surgical Hospital Equipment. Preliminary report, 1 June, 1962.* [n.p.] (Nuffield Foundation; Royal College of Art), 14.11.
[102] Ibid, 9.3-9.5.
[103] Ibid., 10.1.
[104] Ibid., 10.4.

To answer "what sort of device does a sick person in hospital need for sitting or lying in comfort?" the research team searched technical literature, developed a statement of users' needs based on performance specifications in the sense of the subjectively acceptable limits, assigned by the researchers.[105] For example, "adjustment must be quick and easy: The effect of the tilt should not necessarily bring the height of the top of the mattress at the head of the bed to less than 24" from the floor."[106] Forty-one activities (e.g. 7.1"bed as focus of nursing," 7.5 "bed as focus for emergency") and functional properties the bed must possess (e.g. "obvious mode of operation," "stability," "structural transmission of noise") were identified.[107] A prototype was built, tested by Ministry of Health medical personnel, further prototypes built and field trials conducted, every activity at each bed recorded 400 times a day (see Figure 6.10). Patients and nurses were surveyed for impressions, and a study of the energy expenditures of the nurses was conducted. [108] Ergonomics provided the link between the user's needs through the performance specification to the final bed design.

However, it is Archer's association with *Design* which is most responsible for the dissemination of Archer's design method. As historian Christopher Frayling notes, Archer's six-article series "Systematic Method for Designers" "are probably the most influential series of articles ever to appear in that publication."[109] Published in 1963, reissued as a CoID pamphlet in 1965, presented at the 1967 "Conference on Design Methods in Architecture," and most fully developed in his

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[105] L. Bruce Archer, "4th General Assembly of the ICSID, Vienna, 1965." Quoted in Ken Baynes, *Industrial Design & the Community* (London: Lund Humphries, 1967), 47.
[106] Quoted in Ken Baynes, *Industrial Design & the Community* (London: Lund Humphries, 1967), 47.
[107] Ken Baynes, *Industrial Design & the Community* (London: Lund Humphries, 1967), 46.
[108] It was coordinated by Archer under this method and designed by Kenneth Agrew. All design decisions were recorded, but Agrew did not proceed directly through the problems. Ken Baynes, *Industrial Design & the Community* (London: Lund Humphries, 1967), 49.
[109] Christopher Frayling, *The Royal College of Art: 150 years of Art and Design* (Lion and Unicorn Press, 1987), 179.

dissertation, this method hinges upon designing as a form of probabilistic decision making.[110] Indeed, he postulated that it is possible "that all decisions are based upon some implicit or explicit assessment of the probability and. consequences of the alternative outcomes, based upon some system of values," that all decisions are made on the basis of the intuitive calculation of probabilities.[111]

As Gerd Gigerenzer states in *Empire of Chance: How Probability Changed Science and Everyday Life*:

> Around 1960, our understanding of cognitive processes such as perception and thinking was radically transformed by a new metaphor: the mind as statistician. Questions such as how does the mind discriminate between two sounds, recognize an object as a person, attribute a cause to an event, or solve a problem, were approached from this new point of view. Brain functions are today described in terms of calculating probabilities and likelihood ratios, taking random samples, setting a decision criterion and estimating prior probabilities. This metaphor emerged about the same time as another, similarly powerful one: the mind as computer.[112]

Indeed, Archer's design method was mobilized by transactional psychology, which embraced a concern of humans as intuitive statisticians. The transactional psychologists were a group of American psychologists, the majority of whom were united under an Office of Naval Research contract to study "the total personality operating within its total environment" and, particularly for military applicability, "man's method of adjustment to internal and external stress."[113]

The transactionalist William Ittelson embraced considering human minds as computers performing intuitive statistics:[114]

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[110] L. Bruce Archer, *Systematic Method for Designers*, (London: Council of Industrial Design, 1965); L. Bruce. Archer, "The Structure of Design Processes," Ph.D. Dissertation, Royal College of Art, 1967. (Springfield, Va.: U.S. Dept. of Commerce, National Bureau of Standards, Distributed by Clearinghouse for Federal, Scientific and Technical Information, 1969).

[111] L. Bruce. Archer, "The Structure of Design Processes," Marginal Note 84.

[112] Gerd Gigerenzer, *The Empire of Chance*, 203.

[113] G.N. Raines, "Foreward," iii, in Franklin P. Kilpatrick, ed., *Human Behavior from a Transactional Point of View*, Contract Nonr-496 (01), Institute for Associated Research, Hanover, N.H., 1952.

[114] Ittelson became a formative figure for the Environmental Design Research Association in the 1970s.

> Each assumption is undoubtedly weighted on a probability basis. That is assumptions which have frequently and consistently proved valid in the past will tend to be weighted more heavily. ... One psychological result of any action is a change in the probabilities unconsciously assigned to the particular assumptions on which that action was based. The probability is changed in proportion to the weight given to that particular experience, resulting in new assumptions, new predictions, new externalize significances.[115]

Then, like Wiener, McCulloch and Abercrombie, Ittelson linked mental disorders to an improper processing and organization of information. The goal of therapy is to reorder this distribution of information so that the patient may become a more successful intuitive statistician:

> We must assume that the person who comes for therapy has certain misperceptions of the world about him and here by misperceptions we mean specifically perceptions which give him predictions for actions which do not, in turn provide him with the satisfactions he seeks. That is, his perceptions lead to actions which do not for him how the consequences he predicts.
>
> ...What we have referred to as perceptual reweighing undoubtedly takes place first, although dramatically different perceptions and hence different ways of acting may emerge from this process. There is no basic change in the individual's assumptions but rather a reordering, reshuffling, the shifting of relative importance of modes of perceiving which he has already brought with him to the occasion. This is probably the kind that occurs in relatively short-term or supportive therapy in which no basic changes in personality are achieved. The second kind of perceptual change which we have referred to as perceptual relearning involves the formation of entirely new and different assumptions as such. ...The correspondence to the changes which occur in deep therapy with attended basic personality changes.
>
> All of this implies that the focus of therapy is as we have previously stated not inappropriate behavior, but rather inappropriate modes of perceiving. Psychotherapy aims at changing perceptions over changing behavior... changing perceptions for new predictions on which actions are based.[116]

Archer is quite clear that all design decisions must be made on the basis of probabilities: "the choice of any course of action should be based upon the value of the consequences and the probability that

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[115] William H. Ittelson, "Perception and Transactional Psychology" In *Psychology: A Study of Science*, ed. Sigmund Koch, Vol. 4 (New York: McGraw Hill, 1962), 678- 679.
[116] ibid., 700

they will occur."[117]

Technical adaptation is portrayed as the same as a psychological definition of adaptation. For example, Archer states that "in the normal course of evolution one expects that dishwashers will adapt themselves to accommodate awkward dishes and that dishes will adapt themselves to dishwashers."[118] The design environment is devised as a physical fact, rather than a fact to be constituted. The designer is seen as thrown into an environment to which she must submit, rather than structuring her environment at the same time as developing her capacities as a designer.[119] Yet, as historian of science Georges Canguilhem states, in dealing with human norms it is necessary to acknowledge that they are determined as human's possibilities for action in a social situation, rather than (as Archer depicts them) as an organism's functions envisaged as a mechanism coupled with the physical environment.[120] The form and functions of the designed artifacts are the expressions not only of conditions imposed on objects by the environment but also of socially adopted modes of living in the environment.

Using the example of Burgundy, Archer holds it is possible to discover the considerations which ought to constitute designed objects, such that these considerations are independent of the operations of knowledge.

> Descriptive aesthetics is a natural science, like physiology, and ethical aesthetics is a practical science, like philosophy...Natural (or physical or pure) science seeks to understand the nature of phenomena, but passes no judgement upon them. Practical science, on the other hand, seeks to pass judgements, to help the man with a problem to choose what to do...Technology, too, is concerned with helping man to choose what to do. However, technology is concerned with problems about means.... When, say, a wine taster evolves...criteria for the purpose of classifying wines, he is practicing descriptive aesthetics....His task is to apply the test of precedent. The

[117] L. Bruce. Archer, "The Structure of Design Processes," Marginal reference 101
[118] L. Bruce Archer, "Design Analysis 19: Dishwasher," *Design* 143: 60.
[119] Georges Canguilhem, *The Normal and the Pathological* (New York: Zone Books, 1989), 283.
[120] Georges Canguilhem, *The Normal and the Pathological*, 268-269.

actual aesthetic judgement is performed when the body of informed opinion declares the wine fit or unfit to be added to the collection of good Burgundies. This judgement may be represented by - even predicted by - the tests evolved by the wine taster. But the final judgement is not dependent upon, and sees no immutable truths in the tests evolved by wine tasters.[121]

Facts of descriptive aesthetics are separable from values of ethical aesthetics such that facts are free of the tests methods. Facts are not thought conditioned by the theory or means through which they are constituted. Normative theories upon which tests were based we thought separable from the objective interpretation of results: Tests were thought not to subject results to alteration, despite the technical preparations involved.

Value judgments, in turn, are subject to measurement provided on a judicial normalization:

Most stable value judgements are built up like the case law of our courts of justice. Each judgement is based upon precedent. Each decision is added to the collection of judgements, and each added decision changes both the norm or 'centre of gravity' and the field of application of the collection. The next decision is thus made on criteria different from those on which tho previous decision was based. In stable conditions), a consistent but gradually adapting standard is reached...Moreover, unless the new consignment is an absolute orthodox, average example, it will have shifted the 'centre of gravity' of the collection...by which the next consignment will be judged. If for example, it exhibits a somewhat dryer flavour than the norm of the collection so for, and yet is accepted, then either the norm or the tolerance for Burgundy flavour is shifted slightly towards dryness. If its colour is lighter, and yet is accepted, then the norm, or the tolerance is moved slightly towards paleness ...Each individual ...may or may not enumerate the qualities, such a bouquet and body, which particularly please him, and may or may not indicate that these qualities override the abnormalities of dryness and colour.[122]

What is considered normal can only be obtained by a normative, or standardizing, project. The normal is the standard exhibited in the fact. To define abnormality in terms of design maladaptation, as in the creation of the Burgundy, accepts the idea that the designer must subscribe to the fact of a

[121] L. Bruce Archer, "Systematic Method for Designers part 1: Aesthetics and Logic," *Design 172*: 48-49.
[122] L. Bruce. Archer, "The Structure of Design Processes," 8.13-8.15.

norm, and must accommodate to it as to a reality. In the relationship of the fact is then a relationship of exclusion between the normal and the abnormal.[123] A gastronomical norm is not in axiological opposition to a logical norm, yet the ab-normal is the normal's logical negation. The designer must subscribe to the facts of the norms of taste.

This reality is simultaneously an economic good.[124] As Archer writes,

> Design - or industrial design anyway - is essentially the art of reconciling factors drawn from the competing disciplines of function, marketing and manufacture. The weighing of a functional improvement against the economic cost, and of a selling point against the difficulties of manufacture, and of popular preference against expert evaluation - these are the very essence of designing.[125]

The logic of technological normalization and the interest of the economy are placed in the same terms as that which the designer must accommodate.

The establishment of statistics and their utilization through computers is an essential precursor to normalized planning.[126] Here it is the simulation of the use of the computer, the techniques of the computer, which are employed for design devised as planning.

> Systematic methods of problem solving [are] borrowed from computer techniques, for the assessment of design problems and the making of design decisions in the face of conflicting requirements. ... The designer's special problem is that he must usually foresee the probable future choice of other people, as well as his own.[127]

Design becomes solely a form of planning, through an explicit attempt to apply cybernetics, Operations Research, and game theory to designing. This in turn hinges upon designer as information-processing statistician:

According to information theory, the information content of a signal is proportional

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[123] Georges Canguilhem, *The Normal and the Pathological*, 243.
[124] Ibid., 283.
[125] L. Bruce Archer, "Systematic Method for Designers part 1: Aesthetics and Logic:" 48.
[126] Georges Canguilhem, *The Normal and the Pathological*, 282.
[127] L. Bruce Archer, "Systematic Method for Designers part 1: Aesthetics and Logic:" 47-49.

> to the degree to which it narrows the field of remaining uncertainty. For example, the discovery that a component in a design needs to be electrically insulating immediately narrows the field of choice of materials from which it can be made. If it also needs to be heat-resisting, this narrows the field again.
> The unit of information content is the 'bit', or binary unit of information, and is defined as that which halves the uncertainty.
>
> The purpose of a design project is to identify the requirements of a product and to describe a design calculated to meet those requirements. Every piece of data gathered, and every decision made, contributes to reducing uncertainty about the nature and effectiveness of the end product. The measure of efficiency of the design act is thus the measure of the information content of the data employed and the decisions made. Any time, effort or other resources expended in the design act which does not reduce uncertainty about the requirements, nature and/or effectiveness of the end product is wasted.[128]

Waste is deterged as informational uncertainty.

The entire endeavor of mental testing and design method pedagogy was enormously supported. In the US, institutions from the Carnegie Foundation to the National Science Foundation to Dow Chemical all contributed extensive resources for the support of these inquires into creative personalities. In the UK, the contributions were on a smaller scale but specifically supported by the UK government, through the British Government's University Grants Committee's allocations. The UK government also provided financial support to the non-profit National Foundation for Education Research Foundation which actively developed student personality tests. Furthermore, this research into creative personality testing was supported through nonprofit institutions such as the Leverhulme Trust - not to mention the support given to Llewellyn-Davies at the NPHT.

This chapter describes a portion of a path, a "scientific revolution" in the words of Susan Hunt and John Musgrove, in British architectural pedagogy that lasted for over fifteen years.[129] The Bartlett and several other university architectural research endeavors such as Leslie Martin's Centre

128 L. Bruce. Archer, "The Structure of Design Processes," 9.11-9.12.
129 Susan Hunt and John Musgrove, "Schools of Architecture and the Profession," *Architects' Journal* 167, no. 24 (June 1978): 1153.

for Land Use and Built Form at the University of Cambridge increasingly turned to statistical analysis in the 1970s.[130] It is worth noting that the statistical normalization of student personality prefigured much of the statistical analysis of building form. Although student protests echoed across British campuses in the late 1960s, critiquing rationality and technicism, it was not until the late 1970s that university-supported 1970s design pedagogies widely turned to phenomenology, neo-Marxism and radical critiques of science. However, the next chapter investigates some seeds of discontent with information processing models of design which took the normal as statistical average.

[130] Lionel March, "Modern movement to Vitruvius: Themes of Education and Research, " *Royal Institute of British Architects.Journal* 81, no. 3 (Mar 1972): 101-109.

Chapter 7 - Norms of Conflict and Communication: Alexander's Reception, 1967

By the mid-1950s, Christopher Alexander had grown dissatisfied with the concrete possibilities of his method in *Notes*. After *Notes* and prior to developing his 1970s theories of a "Pattern Language," Alexander began developing, with the architect Barry Poyner, an approach they termed Relational Method. This was while Alexander was a visiting researcher at the Offices Development Group (ODG) of the UK Ministry of Public and Building Works (MPBW) in 1965-66. The ODG was engaged in various governmental architecture commissions, from the rebuilding of Whitehall under Leslie Martin to the development of workshops for blind and prison populations.

This chapter contends that the work of Alexander and his associates at the ODG continued a norm of architects and users of architecture as information processors. It also argues that Relational Method works in the same way as the plans of cognitive science and artificial intelligence. However, by 1967, this chapter continues, the ideal of design as information processing was challenged by participants of the 1967 "Conference on Design Methods in Architecture." These dissenters particularly stood against the work of Alexander and associates at the ODG. Following the tenets of a parallel movement in anti-psychiatry, design methods objectors questioned constitutions of normativity permitting the statistical average as the normal and the construction of the normal as conflict free adaptation.

Conference on Design Methods in Architecture

In the fall of 1967, architect Anthony Ward took a position as Research Fellow at the Portsmouth School of Architecture. He had just left the ODG where he had been installed as a research architect along side Alexander. The same day that Ward began his new position at Portsmouth, he suggested to Geoffrey Broadbent they organize a symposium on design methods in architecture.[1]

The conference, which occurred December 4-6, 1967 was attended by over 400 people. Although Alexander was not in attendance - it is not clear why not - Broadbent noted that "perhaps because Alexander is the only architect to have had such an influence in his own field, much of the symposium was devoted to a philosophical and operational analysis of his work" and offered thanks to "Christopher Alexander in his absence, who provided the core of the discussion."[2]

Since we last left Alexander in Chapter Four, he had taken a position as Assistant Professor of Architecture at the University of California, Berkeley. While there he was engaged in the design of the San Francisco Bay Area Rapid Transit subway stations (see Figure 7.1), identifying 390 separate functional requirements in the method proposed in *Notes on the Synthesis of Form*.[3] However, he was dismayed with the rigidity of the results.[4] In 1965 he decried the current use of computers in architectural design as often "trivial over-precision."[5] 1965 also saw Alexander publish one of his best known works, "The City is Not a Tree," in *Architectural Forum*.[6] In this text Alexander refutes the tree structure of cities, as provided in *Notes* and the plan for Bavra, opting for cites depicted as semi-lattices, a non-hierarchical structure of relations he believed corresponded to the organic forms of traditional villages (see Figure 7.2).

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[1] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture, Architectural Association Paper Number 4*, (London: Lund Humphries, 1969), 7, 9.
[2] Ibid., 11-13.
[3]"BART :the Bay Area takes a million-dollar ride," Architectural Forum 124, no. 6, (1966): 38-[61]. Agatha C. Hughes and Thomas P. Hughes, eds., *Systems, Experts, and Computers: the Systems Approach in Management and Engineering, World War II and After* (Cambridge, MA: MIT Press, 2000), chapter 4, for an overview of the rapid transit project. "BART :the Bay Area takes a million-dollar ride," Architectural Forum 124, no. 6, (1966): 38-[61].
[4] Stephen Grabow, *Christopher Alexander: the search for a new paradigm in architecture* (Boston : Oriel Press, 1983), 63.
[5] Christopher Alexander, "The Question of Computers in Design," *Landscape* 14, no. 3 (1965): 7.
[6] Christopher Alexander, "The City is not a Tree," *Architectural Forum* (April 1965): 58-62 and (May 1965): 581-61.

Alexander's Intentionality

When Alexander arrived at the MBPW in 1965, on leave from the University of California, Berkeley, he was installed as a research architect under Ian Moore, the head of the ODG. Moore spoke at the 1967 conference, as did Barry Poyner, with whom Alexander worked most closely at the ODG. Also at the 1967 conference the ODG architects' Keith Hanson and Neville Longbone presented versions of Alexander's methods from *Notes* and "The Atoms of Environmental Structure." "Atoms" is the fullest expression of Relational Method and Broadbent termed the paper "probably Alexander's most significant work to date." [7]

To note, in September 1962, a Team X conference was held at Royaumont, north of Paris. This was a few weeks prior to the 1962 "Conference on Design Methods" (see Chapter Four). At Royaumount Alexander was invited to present on his plan for Bavra, Gujarat. As Peter Smithson recalled, it "was received by Team 10 with a mixture of welcome and skepticism."[8] At Royaumont, Alexander heard the architect Aldo van Eyck present a talk on Piet Blom's "Noah's Ark," an interurban extension between Amsterdam and Haarlem. It was to house a million people in village-like units of ten to fifteen thousand inhabitants. Each unit was comprised of a central square and a radiating windmill pattern. Van Ecyk began with the statement that a house is a tiny city and the city a huge house. The mutual identification of the house with the city was explicitly not to be confused with the analogy of the city with a tree. The city, as a human artifact rather than a natural phenomenon, does not imitate the tree's natural hierarchical structure. "Analogies compare directly. Images identify indirectly through what one may call poetic association."[9] This argument was an

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[7] Ibid., 11.

[8] Alison Smithson, ed. *Team 10 Meetings : 1953-1981*(New York: Rizzoli, 1991), 69.

[9] Quoted in Francis Strauven, *Aldo van Eyck: The Shape of Relativity* (Amsterdam: Architectura & Natura, 1998), 397.

implicit criticism of Alexander's plan for Bavra, based on a tree structure. Alexander appeared to have taken this criticism seriously in his development of Relational Method.

At the1967 conference, Poyner and Longbone presented on Relational Method. The first step in Relational Method is to categorize human purposes, desires, beliefs, feelings, intentions, or, in other words, human intentionality. From the Latin *intentio*, intentionality means being directed towards a goal or thing. The directedness or tension in *intentionality* originates from pointing towards or attending to a target. In Relational Method, human intentionality becomes valid as data for design insofar as there are observable behavioral "tendencies." As Alexander and Poyner write:

> We shall...replace the idea of need, by the idea of "what people axe trying to do". We shall, in effect, accept something as a need if we can show that the people concerned, when given the opportunity, actively try to satisfy the need. This implies that every need, if valid, is an active force. We call this active force which underlies the need, a tendency. A tendency, therefore, is an operational version of a need. If someone says that a certain need exists, we cannot test the statement, because we don't know what it really claims. If someone says that a certain tendency exists, we can begin to test the statement.
>
> ... If we replace [the statement "People working in an office need a view"] by the statement "People working in offices try to get a view from their offices", this is a statement of fact. It may be false; it may be true; it can be tested. It is a statement of a tendency.[10]

Alexander and Poyner treat intentions as though physical actions reflect the underlying mechanism, the mechanisms as an "active force." Intent, made explicit in its sole realization as observable tendency, is identified with a plan-for-action. The actions reflect these mechanisms as a plan that generates the actions.

Alexander and Poyner propose that one is to design an environment with minimal conflict between tendencies. This is to be achieved by locating "relations" which prevent conflicts: "A

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[10] Christopher Alexander and Barry Poyner, *The Atoms of Environmental Structure* (Berkeley: Center for Planning and Development Research, University of California, 1966), 6-7.

relation, then, is a geometrical arrangement which prevents a conflict."[11] This strategy assumes that the behavior of both user and building can be represented in advance as a plan that not only predicts but determines their local interaction. Like cognitive science, it holds a normative view of action in the shape of a planning model.[12] Like in Miller, Galanter and Pribram's *Plans and the Structure of Behavior* (see Chapter Three) it assumes that purposefully acting individuals construct and execute a representation that controls, and therefore serves as a prerequisite to, actions in the world.

The design strategy for Alexander's and Poyner's system is to specify an appropriate linkage between user actions and states of the architectural environment. This is to be captured in an If...Then...statement.[13] Again, like cognitive science, preconditions and postconditions are said to fully describe actions: Preconditions, what must be true to enable the action, and postconditions, what must be true after the action has occurred.

As in Notes, in "A City is Not a Tree" as well, Alexander upholds his views that the human brain is a limited capacity information processor. The semi-lattice, to replace the graph theoretic tree, is unable to be apprehended by "designers, limited as they must be by the capacity of the mind" and thus "cannot achieve the complexity of the semilattice in a single mental act"[14] (see Figure 7.3).

> Modern psychology treats thought as a process of fitting new situations into existing slots and pigeonholes in the mind. Just as you cannot put a physical thing into more than one physical pigeonhole at once, so, by anaology, the processes of thought prevent you from putting a mental construct into more than one mental category at once. Study of the origin of these processes suggests that they stem essentially from the organism's need to reduce the complexity of its environment by establishing barriers between different events which it encounters...The mind's first function is to

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[11] Ibid., 13

[12] Michael Lynch and Steve Woolgar, *Representation in Scientific Practice* (Cambridge, MA: MIT Press, 1990), 308.

[13] Christopher Alexander and Barry Poyner, *The Atoms of Environmental Structure*, 18.

[14] Ibid.

> reduce the ambiguity and overlap in a confusing situation, and because, to this end, it is endowed with a basic intolerance for ambiguity.[15]

Finally, like cognitive science, Alexander reads the intention of actions from the message of behaviors. This "documentary method of interpretation,"[16] takes behavior for an ascribed underlying reality.[17] The Turing Test follows the documentary method of interpretation. In the Turing test, a human judge participates in a conversation with a human and a machine. The machine is said to "think" if the judge cannot tell which is the human and which is the machine.[18] Relational Methods likewise takes appearances, through observable tendencies, as evidence for an underlying reality.

Information Theory among Alexander's Group

After Leslie Martin had developed the concept underlying the rebuilding of Whitehall, Moore prepared the brief for the first stage of rebuilding. As Moore summarized his task, Martin "had found during his research that precious little information was available about office design that was usable."[19] Martin explained that the buildings would be:

> … rooted in a study of use. A development programme will establish these uses and will verify the pattern. The buildings are seen as a developing and growing unit. The first stage can be limited to Bridge Street: if new facts and data emerge then the next stage, eg the Foreign Office, would be adjusted and changed to take these into account. Each stage would be self regulating. The total pattern would lend itself to development without loss of a generating principle and a general sense of unity.[20]

Martin's comment on self-regulation and its cybernetic connotations should not be overlooked.

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[15] Michael Lynch and Steve Woolgar, *Representation in Scientific Practice*, 385.
[16] Harold Garfinkel, *Studies in Ethnomethodology* (Englewood Cliffs, N.J.: Prentice-Hall, 1967), ch. 3.
[17] It takes "that reality so ascribed as resource for the interpretation of the appearance." Michael Lynch and Steve Woolgar, *Representation in scientific practice* (Cambridge, MA: MIT Press, 1990), 305.
[18] Alan Turing, "Computing machinery and intelligence," *Mind* 59 (1950): 433-460.
[19] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture*, 24.
[20] Martin to Anthony Part, 24/08/65, quoted in Ian Rice, "'Ziggurats for Bureaucrats': Sir Leslie Martin's Whitehall Plan" *ARQ* 8, nos. 3/4 (2004): 318.

In dealing with the task of accumulating user information, Moore noted there was a gap of understanding between the government client, the employee users and the architect. This necessitated a full-size simulation mockup. The mockup was seen as a more effective means of eliciting client and user response than drawings or scale models.[21] The simulation "left a series of messages" for the client and the user. [22]

Moore's designs for Prince Consort House recommended an open floor plan because of its greater "adaptability " and "control."[23] It included the design of experimental furniture based on recorded adaptation patterns of workers to office layout. The furniture was referred to in terms shared largely with computer architecture: each worker was to have a "communications unit" and a "storage unit" (see Figure 7.4). [24] The separations of information machines into storage, selection, transmission and processing that was reflected in norms of designing in previous chapters was constituted here in a physical separation of objects in these very terms.

Neville Longbone, a research architect with the ODG, presented on "The physical organization of sheltered workshops for the blind," in which all problematics of design and user intentionality are viewed as issues in limits in information flows. He asserts that the blind are unable to communicate their desires, their intentions, into design prescriptions.[25] Limited patterns of movement were thought to show the physical form and information (sensory stimulation) that the blind use in environmental situations. Limits on patterns of behavior were attributed to limits on incoming information, due to blindness.[26]

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[21] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture*, 25.
[22] Ibid., 25.
[23] Ibid., 26.
[24] Ibid., 26.
[25] Ibid., 180.
[26] Ibid., 182.

Physical forms and sensor stimulation were seen as a function of limited information. Behavioral patterns are correlated with the form and limits of information.[27] Like Wiener and McCulloch (see Chapter Three), Abercrombie and the Transactionalists (see Chapter Six), the disorder of how the blind navigates a physical environment is a fault of inadequate information transfer. The organization of the pattern of the workshop is then to be a function of information flows[28]: one must design a workshop for which the order of information flows to the blind conduce conflict free adaptation (see Figure 7.5). This is achieved through using Relational Method: locating tendencies, conflicts, and relations which will minimize the conflict between tendencies (see Figure 7.6).

Poyner presented "The Evolution of Environmental Structures," a discussion of his and Alexander's Relational Method (see Figure 7.7). Evolution, in its progressive and biological connotations, resonates in the work of the philosopher of science Karl Popper. Popper's work was leveraged by Alexander and the larger British architectural community. For example, Reyner Banham said in the mid 1960s that those interested in thinking architecture through new fields such as indeterminacy and open systems "were certainly reading Professor Karl Poppers' *The Open Society*." [29] Furthermore, Popper's piece "Of Clocks and Clouds" appeared in abbreviated version in a 1969 issue of *Architectural Design*.[30] In examining Popper, I hope to put into dialogue the ubiquity of the infiltration of cybernetics and information theory for architectural design practices.

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[27] Ibid., 185.
[28] Ibid.
[29] Reyner Banham, "Revenge of the Picturesque: English Architectural Polemics, 1945-1965," in John Summerson, ed., *Concerning Architecture; Essays on Architectural Writers and Writing presented to Nikolaus Pevsner* (Baltimore, Penguin Books, 1968), 270.
[30] *Architectural Design* (September 1969)

In "Of Clocks and Clouds," aspects of which Popper would develop fully in *Objective Knowledge*, the operative mechanism at work in the growth of knowledge is captured in the following phrase:

$$P_1 \rightarrow TT \rightarrow EE \rightarrow P_2$$

An organism confronted with a problem (P_1), proposes a tentative theory or solution (TT). This is then subjected to error elimination (EE), through which a new problem arises (P_2).[31] Problem-solving regulated through error-controlled feedback is proposed applicable from bees to scientists. It is an evolutionarily cybernetic outlook, in which the tentative theory works like a prediction. The theory is then falsifiable through its being subjected to error elimination.

In Poyner and Alexander's work, a tendency is an observable need, a need "operationally defined" so as to be a testable statement.[32] A tendency is equivalent to an hypothesis, as both are "an attempt to condense a large number of observations by means of a general statement" and subject to disproof.[33] A conflict may or may not exist between tendencies, but to achieve a design without conflict, "the designer must try to predict all the conflicts that could possibly occur in it."[34] Relations are geometrical relationships, themselves hypotheses, of the form "if such and such conditions hold, then the following relation is required" to prevent conflicting tendencies.[35] Tendency, conflict and relation are presented as falsifiable hypotheses, testable under specific conditions and stated as deducible predictions in the form of if-then statements.

Tendencies take the form of Popper's if-then causal theories, which is consistent with his feedback loop of problem-theory-eliminate-problem presented above. Popper writes that universal

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[31] Karl Popper, *Objective Knowledge* (Oxford: Clarendon Press, 1972), 114.
[32] Christopher Alexander and Barry Poyner, *The Atoms of Environmental Structure*, 4, 6.
[33] Ibid., 7, 15.
[34] Ibid., 15.
[35] Ibid., 12, 15.

statements, "i.e. hypotheses of the character of natural laws," together with singular statements or initial conditions, permit the deduction of singular predictions.[36] In "Atoms," if-then hypothetical statements are said to be falsifiable statements, which operate from given conditions to predictions of (non-conflicting) geometrical relations.

For Popper, the difference between humans and computers is solely the level of indeterminism.

> Cybernetics and computer engineers have more recently succeeded in constructing computers made of hardware but incorporating highly plastic controls; for example, computers for built in mechanisms for chance-like trials, checked or evaluated by feedback (in the manner of an automatic pilot or self-homing device) and eliminated if erroneous. But these systems, although incorporating what I have called plastic controls, consist essentially of complex relays of master-switches. What I was seeking, however, was a simple physical model of ... indeterminism; a purely physical system... Conscious states, or sequences of conscious states, may function as systems of control, or error-elimination: the elimination, as a rule, of (incipient) behavior, that is (incipient) movement. Consciousness, from this point of view, appears as just one of many interacting systems of control;...Consciousness in turn is, we may conjecture, produced by physical states.[37]

It is in the ability to simulate consciousness from physical machine-states running software that Herbert Simon's project sought the formal conditions of cognitive activity common to humans, animals or machines. As Jölle Proust has shown, Simon's project sought, like Popper's, to discover the necessary and sufficient *a priori* conditions that grounded the objectivity, the universality, of knowledge and made this knowledge possible.[38] Not only did Alexander seek the *a priori* conditions of environmental structure, but, as I have argued above, the plan which structures human behaviors for Alexander is fully captured in the software programs of cognitive scientists.

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[36] Karl Popper, *The Logic of Scientific Discovery* (New York: Basic Books, 1959), 59, 60, and see also Section 12, 59-77; Karl Popper, *The Open Society*, vol. 2, (London: Routledge & K. Paul, 1945), 249, 342.
[37] Karl Popper, *Objective Knowledge*, 248-251.
[38] Joelle Proust, "L'Intelligence Artificielle comme Philosophie," *Le Debat*, no. 47 (November-December, 1987): 88-102.

To continue the cyborg advance upon Popper's philosophy of science, Shannon's communications theory postulates concerning information content parallel Popper's discussion of the information content of hypothesis. As Warren Weaver phrased the treatment of information in communications theory:

> Information is, we must steadily remember, a measure of one's freedom of choice in selecting a message. The greater this freedom of choice, and hence the greater the information, the greater is the uncertainty that the message actually selected is some particular one. Thus greater freedom of choice, greater uncertainty, greater information go hand in hand.[39]

Information is associated with choice from a preexisting menu of symbols, which comprise a message in information theory. In a colorful description by Phillip Mikowski, Shannon's "choice" is viewed as an experiment in telepathy:

> There is a source of "information" arranged by some external experimenter (a pack of cards), a transmitter (here, the putative telepath), a signal (a black circle on a card), a channel (the ethereal medium?), possible some noise (static in the astral plane; distractions for the telepath), and a receiver (a talented "sensitive" in another room). Shannon would imagine that it is a job of the telepath to send the image of the circle to the other room, devoid of any concern for their meaning or significance. Indeed, it is the role of the experimenter to control all the important semantic characteristics of the symbols so they do not influence the experiment. The experimenter "chooses" which symbols to transmit at random, guided by full knowledge of the prior distribution of the inscribed cards. Shannon then asserts that it is possible to formalize the "amount of information" conveyed by the signal solely by the probability of its "choice."[40]

Returning to Popper:

> I have shown that the testability of a theory increases and decreases with its information content and therefore with its improbability (in the sense of the calculus of probability). Thus the 'better' or 'preferable' hypothesis will, more often than not, be the more improbable one....My main arguments are very simple (content =

[39] Warren Weaver, "Recent Contributions to the Mathematical Theory of Information," in Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communication*, 18-19.
[40] Phillip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (New York: Cambridge University Press, 2002), 71.

improbability).[41]

In communications theory, the lower the probability of a message the higher is the information content. For Popper, the lower the probability of the theory the higher is the information content.

Now, to resume discussion of Alexander and Poyner:

> We believe that all values can be replaced by one basis value: everything desirable in life can be described in terms of the freedom of people's underlying tendencies. Anything undesirable in life - whether social, economic, or psychological - can always be described as an unresolved conflict between underlying tendencies. Life can fulfill itself only when people's tendencies are running free. The environment should give free rein to all tendencies; conflicts between people's tendencies must be eliminated.[42]

Value stands in the same relation to freedom of choice as does Shannon's information content to freedom of choice. Value is a function of freedom of choice from a set of pre-established tendencies, those observed and mapped by the architect onto the "atoms of environmental structure" - as from a preexisting menu of symbols.

Norms of Conflict

Alexander's uses of information theory and cognitive science are not so much significant because Alexander generally absorbed the findings of another discipline into architectural design, but rather because of the specifics of how these extra-architectural discourses constructed what were considered "normal" behaviors for a user within a built environment and the resistance to these constructions of "normal" by other members of the 1967 conference. Objections to Alexander's

[41] Karl Popper, *Objective Knowledge*, 17.
[42] Alexander and Poyner, *The Atoms of Environmental Structure*, 16.

assumptions were advanced at the 1967 conference by the conference co-organizer Anthony Ward, the architect Amos Rapoport and the philosopher Janet Daley.

Rapoport questioned two of Alexander's fundamental assumptions: one, that conflict free adaptation defines normality; and two, that facts in the judgment of conflict free adaptation are non-normative. In "Atoms," for example, the normal is defined as conflict free adaptation:

> If [a man sitting in a chair] is trying to read, he needs enough light to read by. If he sits in his chair long enough, he will need food or refreshment. He needs ventilation. Under normal circumstances, he is perfectly able to meet these needs for himself. But if we define a good environment as one which meets needs, we should logically be forced to design an environment which meets these needs for him.
>
> ...Under normal conditions each one of the tendencies which arises in this situation can take care of itself. The man can do everything for himself. There is no problem in the situation. The environment does not require re-design. If needs are defined as tendencies, and if tendencies are capable of taking care of themselves, then why does the environment ever require design by designers? Why can't tendencies always be left to take care of themselves? ...
>
> The answer is this. Under certain conditions, tendencies conflict. In these situations, the tendencies cannot take care of themselves, because one is pulling in one direction, and the other is pulling in the opposite direction. Under these kinds of circumstances, the environment does need design: it must be re-arranged in such a way that the tendencies no longer conflict.[43]

Norm is opposed to individual adjustment and variation. Conflict free adaptation as the norm of normal assumes no necessary variation of the individual organism. As such, Alexander proposed what essentially resolves to a physics of mental well-being, predicated upon conflict free adaptation.

> It has been shown that certain arrangements of seats in the wards of mental hospitals can double the recovery rate, because they induce the right kinds of social interaction, there should be rules which promote these kinds of arrangement.[44]

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[43] Christopher Alexander and Barry Poyner, "Atoms of Environmental Structure," 9-10.

[44] Christopher Alexander, The Coordination of the Urban Rules System (Berkeley: Institute of Urban and Regional Development, Center for Planning and Development Research, University of California, 1966), 12.

Furthermore, these rules are to be based on "facts" rather than "values:" the concept of tendency Alexander elaborates, taking the form of a testable hypothesis, an if-then statement, is to generate environmental facts:

> But if we replace [a statement of "need"], by the statement "People working in offices try to get a view from their offices", this is a statement of fact. It may be false; it may be true; it can be tested. It is a statement of a tendency.[45]

The statements, then, that Alexander makes are to be questions of fact rather than questions of value, statements such as: "those in industrial society act in abnormal ways...what is nowadays considered "normal" urban behavior is strikingly like schizophrenia."[46]

As Rapoport stated:

> Not only has it been suggested that some conflict may be necessary and indeed desirable, but modern architecture has been criticized for being too dedicated to the elimination of conflict. The very decision as to what constitutes conflict and which tendencies in man are innate also involves value judgements.[47]

Rapoport's objection was that concepts of conflict, their codification as pathologies, are not separable from values. In other words, classification schemes are theory laden.

Ward and Daley objected to the normal as conflict-free adaptation and the normal as statistical average. For their arguments they leveraged the work of psychologist Ronald Laing. A reviewer of a recent monograph on Laing wrote:

> R. D. Laing was one of the most influential critics of psychiatry in the 1960s and never failed to spark controversy. He was a rather narcissistic social activist who was always eager to appear in the public limelight, partly because he required speaker fees and book royalties to maintain his lavish lifestyle. Remembered by students as drunk by lunchtime, staggeringly rude but still amazingly charismatic, his writings still inspire a number of conscientious psychotherapists who are concerned with the often

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[45] Christopher Alexander and Barry Poyner, "Atoms of Environmental Structure," 7.

[46] Christopher Alexander, *The City as a Mechanism for Sustaining Human Contact* (Berkeley: Center for Planning and Development Research, University of California), 25-26.

[47] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture,* 139.

less-than-stellar role of psychiatry in modern society.[48]

A psychiatrist and psychoanalyst through the 1950s and 1960s at the Tavistock Clinic in London, Laing believed that mental illnesses such as schizophrenia are not illnesses but rather modes of being which serve as coping mechanisms for individuals to live in unlivable situations. In 1965 Laing was a founder of the Philadelphia Association, which ran residential communities - the most well known being Kingsley Hall (1965–70) - in which schizophrenics could find sanctuary and make their own "journey through madness" unimpeded by conventional psychiatric treatment.

There are two distinct conceptualizations of the normal in Laing's work. In *The Divided Self*, from 1960, a normal individual is one said to obtain a sense of "primary ontological security." The normal individual is viewed as one who enjoys a stable and continuous sense of identity, a feeling of personal autonomy, and has the ability for "authentic self-disclosure." Laing writes: "My thesis is limited to the contention that the theory of man as a person loses its way if it falls into an account of man as a machine or man as an organismic system of it-processes."[49] His contention is that the treatment of humans as analogous to machinic objects, such as in cognitive and information processing psychology, loses human's essential humanity.

Ward would employ the sense of normal from *The Divided Self*, as an individual with "primary ontological security."

> We [designers] accept the *values* of society (or the majority of it) as a starting point. At no time do we actually treat the user as our equal, as a designer in his own right. We never, for instance, ask the user what kinds of questions he would like to answer. We always give him questions which *we* want *him* to answer...We see only our capacity to give society the forms it wants, and reject our ability to actually create a new social order through physical organization. This results in what Laing has called 'ontological insecurity' - an overdependence upon others for one's own existence, an

[48] Hans Pols, "The Crucible of Experience: R. D. Laing and the Crisis of Psychotherapy (review)," *Journal of the History of Medicine and Allied Sciences* 57, no. 4 (October 2002): 510-511.
[49] R.D. Laing, *The Divided Self* (New York: Pantheon Books, 1969), 21.

almost pathological tendency to be dependent upon others for one's sense of one's self [emphasis original].[50]

Parcel to this is a rejection of the normal as the statistical average:

> Current social science theories consider any form of deviance as a social or statistical problem. A small minority of people are judged to be deviant *because they are a minority.* This concept of madness or deviance is administrative...A sensible approach to the problem of deviance must stem from the understanding that a person is *abnormal within himself,* and no amount of recourse to consensus values can otherwise justify the label. This administrative notion of normality seems at present to be applied in design situations [emphasis original].[51]

Ward rejects the normalization project of erasing individual differences through the use of statistical average and in terms of deviations from statistical average.

Ward sees the goal of designing as environmentally assisting the search for this sense of the normal person as one possessing individual autonomy and "primary ontological security."

> *In a successful solution it is therefore possible for the person to progress from a state of complete dependency to a state of being totally independent...*Design is a problem of assisting individuation and the designer can only be successful when he becomes superfluous. Present facilities prevent this kind of success. We desperately need a (phenomenological) method perhaps of a similar kind to the one which Laing has found necessary to create in the field of psychiatry, for we are basically concerned about the same problem [emphasis original].[52]

Whereas the earlier approaches to methods of design were, as I have argued, information processing methods, Laing offered an alternative theory of communication. Laing contended that to provide a theory of communication which offers a genuine interpersonal interaction between the self and an other is to include a place for 'you.' "The 'you' is as primary as the I. In Freud's theory, for instance, "one has the 'I' (ego), the 'over-me' (super-ego) and 'it' (id), but no you."[53] It is essential for Laing's theory of communication to include the first person's perception of him or herself as well as the way

[50] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture,* 172.
[51] Ibid., 173.
[52] Ibid., 177-178.
[53] R.D. Laing, H. Phillipson and A.R. Lee, *Interpersonal Perception* (London: Tavistock, 1966), 3.

the first person perceives the other. Nesting these perceptions then includes the first person's perception of the other's perception, such as "I suppose she thinks that I am afraid of her." Note that the including the "receivers" perception of the "transmitter," or, that the observer alters the situation of communication, is not modeled in Shannon's mathematical theory of communication.

Furthermore, Ward, who had worked with Alexander in the ODG, uses Laing to reject Alexander's belief that the avoidance of environmental conflicts is the goal of built form.

> Before a person can perceive the environment's capacity for change he has first to conceive his capacity to change it and this requires a sense of self (which can only be acquired by active participation with the environment)... *It is not enough simply to produce large, open, flexible, spaces, because one has first to be able to produce enough stress in the person to overcome his basic inertia* [emphasis original].[54]

Rather than normality as conflict free adaptation, Ward advocates that conflict can be conducive to positive change, aiding in the beneficial individuation of a building's inhabitants.

By the time of *The Self and Others*, in 1962, Laing changed to define normality as a state of unconscious complicity in "social phantasy systems," such as scientism and political ideologies: "the normal state is to be so immersed in one's immersion in social phantasy systems that one takes them to be real."[55] In his 1967 *The Politics of Experience*, the Freudian normal subject is pressed as the product of a self ruined:

> What we call normal is a product of repression, denial, splitting, projection, introjection and other forms of destructive action on experience...The condition of alienation, of being asleep, of being unconscious, of being out of one's mind, is the condition of normal man.[56]

It is scientism and mass social ideologies which Laing sees as destructive in contemporary culture. Contemporary culture's concern with reality as such is itself depicted as a mass hallucination:

[54] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture*, 173.
[55] R.D. Laing, *The Self and Others* (New York: Pantheon Books, 1969), 23.
[56] R.D. Laing, *The Politics of Experience*, (New York: Pantheon Books, 1967), 22-24.

> The tremendous social realities of our time are ghosts, specters of murdered gods and our own humanity returned to haunt us...the fabric of these socially shared hallucinations is what we call reality, and our collusive madness is what we call sanity.[57]

Referring to behaviorism as mainstream psychiatric treatment, Daley uses the notion of Laing's mass societal illusion to argue that the abnormal, those who fail to manifest conflict free adaptation, are not mentally ill but rather those who are the more reasonable beings:

> Behaviourism in practice (practices including aversion therapy, the exclusive use of drug and electric shock treatment) implicitly and unavoidably regards the *utility* and *conformity* of the human being as a societal unit, as the ultimate and all-embracing value. Evaluating the worth of the demands of a given society *on* individuals is *practically* and *morally* beside the point: it is the individual who must be made to fit, made to be socially viable - a 'useful citizen' in the most harrowing and relentless sense...society and its internal coherence must be preserved; non-functioning units of the communal organism must be 're-conditioned'...[W]hat *must* be considered is that the insane or the neurotic are different and perhaps more complex kinds of *dissenters:* society's drop-outs who could not, or would not play the game, *perhaps with good reason...*What if the world were really intolerable? Would it do to 're-condition' all those sensitive enough to find it so?[58]

Her objection to Alexander is that his architectural methods treat cultural values as facts, and these values explicitly encourage the mass illusion of the "normal" as conflict free adaptation.

It is relevant to note that the authentic self is associated for Laing with the innocent child. This idealized child figure, unwarped by alienation, is replete with the liberated unconscious of fantasy and dream. For Laing:

> As adults, we have forgotten most of our childhood, not only its contents but its flavor; as men of the world, we hardly know of the existence of the inner world: we barely remember our dreams, and make little sense of them when we do; as for our bodies, we retain just sufficient proprioceptive sensations to coordinate our movements and to ensure the minimal requirements for biosocial survival . . . an

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[57] Ibid, 73

[58] Geoffrey Broadbent and Anthony Ward, eds., *Design Methods in Architecture*, 112.

> intensive discipline of unlearning is necessary for *anyone* before one can begin to experience the world afresh, with innocence, truth and love [emphasis original].[59]

. A return to childhood innocence was given empirical validity for architectural education by seeing design as a form of therapy. For example, consider a phrase by the head of the Nottingham School of Architecture in 1962, situated in an issue of *Architects' Journal* adjacent to a photograph of a child cutting paper:

> We do not get the best from students. Blockages in the desire, or ability, to work or think can only be tackled from the point of view of therapy. (Discipline as imposed by those who are in authority, having been thoroughly discredited as a method for our times 'should' is replaced by 'why does he not?') To provide opportunity for working the rough complexes, inhibitions and fears (basically the fear of freedom and pleasure) becomes a real need in architectural education.[60]

Characteristic of Sixties utopian writing are the bedrocks of alienation and authenticity.[61] The language reflects that of Sixties counter-culturalists that existing conditions must be changed in total for humanity to realize an authentic self-liberation, indeed, for life to continue in a way meaningful. In rejecting the human as information processor, computer or communications network, dissenters such as Rapoport, Ward and Daley remained distinctly modernist in their project. Architectural change is to be manifest through willed, individual, self-liberation.

The *Architects' Journal* responded to the "Conference on Design Methods in Architecture" that design methods remained a valuable field of research:

> Participation in the symposium...seems to have been sharply divided between those who are confident that all the factors in design are quantifiable and those who question the validity of any quantification in design.
>
> The second of these two groups, which has become very much more vocal in the last year, rouses a national response among architects...

[59] R.D. Laing, *The Politics of Experience*, 26.
[60] Paul Ritter, "Five Realities of Architectural Education," *Architects' Journal*, (*2* May 1962): 942.
[61] Marianne DeKoven, "Psychoanalysis and Sixties Utopianism," *JPCS: Journal for the Psychoanalysis of Culture & Society* 8, no. 2 (Fall 2003): 263-272.

> We have much sympathy with some of the points made by those who question design method as it is: with their contention, for instance, that it gives too much prominence to aspects of design which can be measured at the expense of those which at present can't...
>
> But these observations do not in our view invalidate scientific method as a means of finding out facts which bear on architecture.[62]

However, only three years after the British Architectural Students Association (BASA) adopted a resolution to encourage systematic design methods (see Chapter Six), a BASA reporter stated of the conference with irritation, "There are just too many philosophical questions still to be posed, let alone answered, before buildings can begin to be compared with space ships and motor cars in terms of scientific and methodological achievement...The whole thing was very exhausting."[63]

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[62] "Both Facts and Fancy," *Architects' Journal* (10 January 1968): 51-52.

[63] Roger Bloomfield, "Student Section," *Architects' Journal* (10 January 1968): 65-67.

Chapter 8 - Aftermath: Alexandrian Patterns and New Media

At 78th Street and Central Park West in New York City lies the main access to the American Museum of Natural History (AMHN). Upon entering its imposing stone atrium, after undergoing a security check of one's backpack or briefcase, one proceeds to the west wall, where a flank of friendly customer service representatives efficiently dispense tickets for admission to the museum's displays. If, while waiting for due ingress, one turns back to the southwest wall, the following quote by Theodore Roosevelt is installed in metal lettering mounted high above the milling crowds of tourists and schoolchildren: "NATURE...There are no words that can tell the hidden spirit of the wilderness that can reveal its mystery and its melancholy and its charm."

On a mild day, the walk form the AMNH to the Museum of Modern Art (MOMA) is a pleasant half an hour, largely in view of the largest span of greenery in Manhattan, Central Park. An object in the MOMA's permanent collection, on view in fall of 2007, is a work in oil on canvas from 1966-1968 by John Baldessari titled *What is Painting*. It contains the text "Art is creation for the eye and can only be hinted at with words."

Within their contexts of display, artifacts at the MOMA are processed as aesthetic objects. At the AMNH, artifacts are indices interpreted as nature.[1] Roosevelt invokes a Romantic commitment to the unnamable sublimity of natural experience. Baldasarri summons the historically interminable shuffle of privilege afforded image, text and speech, that such a question is inherently (naturally) undecidable although continually evinced. As the well known quote of Michel Foucault states concerning Diego Rodríguez de Silva y Velázquez's painting *Las Meninas*:

[1] Mieke Bal, "Telling, Showing, Showing Off," *A Mieke Bal reader* (Chicago: University of Chicago Press, 2006), 171.

> The relation of language to painting is an infinite relation. It is not that words are imperfect, or that, when confronted by the visible, they prove insuperably inadequate. Neither can be reduced to the other's terms: it is in vain that we say what we see; what we see never resides in what we say. And it is in vain that we attempt to show, by the use of images, metaphors, or similes, what we are saying; the space where they achieve their splendor is not that deployed by our eyes but that defined by the sequential elements of syntax.[2]

Nevertheless, attempts to treat visual entities through syntax have a history closely bound with the computer related media this dissertation has examined. The conclusion, or more exactly aftermath, presented here details how Christopher Alexander's 1970s work on a pattern language for architectural design drew from attempts to map syntax to spatial and visual concerns. I link this with a recent attempt to create categorical descriptions applicable to new media, or the cultural objects which use digital computer technology for distribution and exhibition.[3] New media is significant because of the increasing hegemony of new media technologies, from art to gaming to digitized text and texts. Furthermore, the link of new media to Alexandrian patterns is important because both retain the logic of the use value of a machine that transforms information, functioning in terms of selection, transmission, storage, and processing. The result is to instate a foundational discourse mobilizing this method of dividing up the world into accompanying components of data.

Pattern Recognition

In the late 1960s, fuelled by the requirements of computational image rendering endeavors and following advances in, most notably, Noam Chomsky's mathematical linguistic theory, syntactic

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[2] Michel Foucault, *The Order of Things* (New York: Random House, 1970), 9.
[3] Lev Manovich, "New Media from Borges to HTML," in *The New Media Reader*, edited by Noah Wardrip-Fruin and Nick Montfort (Cambridge, MA: MIT Press, 2002). http://nothing.org/netart_101/readings/manovich.htm. Accessed September 4, 2007.

pattern recognition began to be developed.[4] Syntactic pattern recognition can describe aspects of a visual pattern that are eligible for assignment in multiple classes. As computer scientist K. F. Fu, one of the early developers of syntactic pattern recognition, explains:

> A typical example of [the syntactic pattern] recognition problem is picture recognition or, more generally speaking, scene analysis. In this recognition problem, the patterns under consideration are usually quite complex and the number of features are often very large, which makes the idea of describing a complex pattern in terms of a (hierarchical) composition of simpler sub patterns very attractive.... consequently, the requirement of recognition can be satisfied only by a description for each pattern rather than by the simple task of classification.[5]

In syntactic pattern recognition, patterns are decomposed into sub patterns and pattern elements based on prescribed syntactic operations. The pattern is then represented as a set of elements with specified syntactic operations.

An input pattern is first coded or approximated by some convenient form for further processing such as filtering and enhancement.[6] Subsequently, the pattern recognition process involves analysis of the coded input pattern through a decomposition of the "sentence" of the pattern representative of the appropriate syntax. This is done by decomposing into a graph-theoretic hierarchical tree structure.[7] Patterns are then classified and described according to their syntax, such that patterns that are syntactically unfit to the prescribed grammar are rejected or not recognized as a member of a particular categorization of patterns. Furthermore, syntactic pattern recognition requires an "inference machine," as Fu explains.

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[4] Lev Manovich, "Modern Surveillance Machines," in *CTRL [SPACE]: Rhetorics of Surveillance from Bentham to Big Brother*. Thomas Y. Levin, Ursula Frohne, and Peter Weibel, eds. (Cambridge, MA: MIT Press, 2002).
[5] K.S. Fu, *Syntactic pattern recognition and applications*, 1.
[6] Ibid, 8.
[7] Ibid, 5.

> In order to have a grammar describing the structural information about the class of patterns under study, a grammatical inference machine is required that can infer a grammar from a given set of training patterns in language like representation.[8]

The grammar is recursive, such that a rewriting rule can be applied any number of times, making it possible to express compactly structural characteristics for an infinite set of "sentences."[9] K.F. Fu indeed draws an explicit parallel between natural language and syntactic pattern recognition:

> The similarity between the hierarchical structural description of patterns... and the structure of a sentence... appears to be quite obvious... Patterns are specified as being built up out of sub patterns in various ways of composition, just as phrases and sentences are built up by concatenating words, and words are built by concatenating characters...the language that provides the structural action of the patterns in terms of a set of pattern primitives in the component operations is sometimes called the pattern description language. The rules governing the composition of primitives into patterns are usually specified by the so-called grammar of the pattern description language.[10]

In syntactic pattern recognition, one selects modular sub patterns and elements or "primitives" based on a prescribed syntactic structure. Variable images are filtered and enhanced for ease of syntax recognition, and the pattern recognition itself is capable of recognizing variable images, so long as they share certain class characteristics. The inference machine "learns" to automatically generate a grammar or algorithm for recognizing a set of patterns. In other words, there is selection of stored modular patterns. Variable images are processed and transmitted to the inference machine. Patterns are automatically recognized by the inference machine through a further algorithmic process. Selection, storage, transmission and processing compose the key elements of syntactic pattern recognition.

The fundamental components of media theorist Lev Manovich's definition of the elements of new media are congruous. First, "media becomes programmable" through media's capacity for formal

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[8] Ibid, 10.
[9] Ibid, 5.
[10] Ibid, 2-4.

(mathematical) representation and algorithmic manipulation.[11] The form of new media can be processed through algorithms. Second, objects of new media are stored modularly, both at the level of representation (like the pattern's syntactical description) and at the level of code (also in which syntactic pattern recognition procedures are written).[12] The modularity thus provides storage on two levels. Third, modularity, formal mathematical representation and its algorithmic accompaniment "allow for the automation of many operations involved in media creation, manipulation, and access."[13] The processing of the media can be automated. Fourth, new media are characterized by its variability, in opposition to the exact reproduction of an "original" object, such as a photograph or printed book.[14] The transmission of the media is variable. Fifth, integral to these properties is a "logic of selection": "Although software does not directly prevent its users from creating from scratch, its design on every level makes it "natural" to follow a different logic - that of selection."[15] Just as pattern recognition creates no patterns, only recognizes them, a user of a web page that consists of links to other pages selects a subset of the total paths possible for selection. The user selects a sub pattern of the total prescribed pattern possibilities. The two further distinguishing facets of new media for Manovich are also aspects of information processing: transcoding, or the process of translation from one medium to another, and that new media exists as a "*modification of an already existing signal* [emphasis original]".[16] In pattern recognition, the inference machine performs a transcoding between a culturally produced image, element by element, into a machine-recognizable structure. The signal of the image is already existent.

[11] Lev Manovich, *The language of new media* (Cambridge, MA: MIT Press, 2001), 27.
[12] Ibid, 31.
[13] Ibid, 32.
[14] Ibid, 37-38.
[15] Ibid, 129.
[16] Ibid, 126.

Alexandrian Patterns

Alexander's patterns fit both principles of syntactic pattern recognition and new media. Alexander began his endeavors into patterns in the late 1960s. However, it was in the latter 1970s that he produced two books, *The Timeless Way of Building* and, with the collaboration of Sara Ishikawa, Murray Silverstein, Max Jacobson, Ingrid Fiksdahl-King, and Shlomo Angel, *A Pattern Language*. Alexandrian pattern language is comprised of a set of elements, or symbols, and a set of rules for combing these symbols.[17] They refer to each pattern as "a morphological law, which establishes a specific relationship in space."[18] Each pattern is a spatial law.

> This morphological law can always be expressed in the same general form:
>
> X -> r (A,B, ...), which means:
>
> Within a context of type
>
> X, the parts A,B,,...are related by the relationship r.[19]

The patterns themselves are "a three-part rule, which expresses the relation between a certain context, a problem, and a solution."[20] Take Alexander et al's following examples:

> Within a Gothic cathedral -> the nave is flanked on both sides by parallel aisles.
>
> Or:

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[17] Christopher Alexander, Sara Ishikawa and Murray Silverstein, *The Timeless Way of Building* (New York: Oxford University Press, 1979), 184.
[18] Ibid, 90.
[19] Ibid
[20] Ibid, 247.

> Where freeway meets an artery -> the access ramps of the interchange take the rough form of a cloverleaf.[21]

In the context of a gothic cathedral, the problem is (implicitly) 'how is the nave situated?' The solution is that both sides are flanked by parallel aisles. Or in the context of a freeway meeting an artery, the problem is (implicitly) 'how are the access ramps structured?' The solution is a cloverleaf interchange.

Notice Alexandrian patterns' participation in the new media properties identified by Manovich. Patterns' variability consist in that "a pattern language gives each person who uses it the power to create an infinite variety of new and unique buildings, just as ordinary language gives him the power to create an infinite variety of sentences."[22] Modularity exists in that "each part is autonomous."[23] The pattern language holds automaticity: "each law or pattern is itself a pattern of relationships among still other laws, which are themselves just patterns of relationships again."[24] Patterns are also algorithmic: "As an element of language, each pattern is an instruction, which shows how this spatial configuration can be used, over and over again, to resolve the given system of forces, wherever the context makes it relevant."[25] Furthermore, the logic of selection is evident in that 236 patterns are given as a catalogue, in the work *A Pattern Language*. Architects or user-builders are then to select the patterns for combination according to the syntax presented. Moreover, the pattern language continues a logic of selection, storage, transmission and processing. There is a variable transmission of selected modular storage units processed automatically and algorithmically.

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[21] Ibid, 90.
[22] Ibid, "Chapter 10," n.p.
[23] Ibid, 163.
[24] Ibid, 90.
[25] Ibid, 247.

By maintaining the logic of the use value of a machine that transforms information, a logic provided in terms of selection, transmission, storage, and processing, Alexander and Manovich's new media tenets are complicit in eradicating a concern with constituting understanding outside this framework. This is problematic because thinking in terms of information selection, transmission, storage, and processing means the world is cut up as data to be operated upon in one of four ways. As such, a new basal underpinning discourse emerges given in these terms. A new nature of human action in the world, a stance from which all other activities proceed, are circumscribed by these categories.

To act abnormally, to evince deviant deeds and thoughts, is opposite to this normativity given in terms of information selection, storage, transmission and processing. A norm can serve as a rule of conduct, a principle of conformity. As such, a norm is opposed to irregularity, unevenness, deviation and strangeness. A norm can also serve as a functional regularity, as the principle of an appropriate and well adapted biological functioning. In this sense the normal is opposed to the pathological, disorganized and dysfunctional. Yet for both meanings, what is normative is what decries a lawless difference. Inherent in the normal is a concept of right. That which resists it qualifies as crooked, twisted or awkward. The normal is a reference for objects which are not in a locus to be named as such. The normal is project of intervention and correction, extending itself through a norm. What does not meet the requirement served by a norm is that which is outside it; a norm draws its value, meaning and function from that which is other than it. As the physician Ehrenfried Albrecht has noted, health, normality, and sickness are determined by socio-cultural conventions and say more about these conventions than wellness or illness themselves.[26] As the philosopher Karl Jaspers wrote,

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[26] Ehrenfried Albrecht, "Grunproblem der Geschwulstleher," *Frankfurter Zeitschrift für Pathologie* 1 (1907).

abnormality is a concept of value that depends more upon the prevailing conception of the socio-cultural sphere than on the judgment of any individual within that sphere.[27] In a normativity given in terms of the use value of a machine that transforms information, disorders are seen in terms of malfunctioning data selection, transmission, processing, and storage capacities. Digressions from these norms are seen as evidence of abnormality. But as the psychologist and neurologist Kurt Goldstein remarked, strangeness and dysfunction ought not be determinable as deviation from a superindividual norm.[28] Not every deviation from the norm should appear as an abnormality. Abnormality can be determined only by means of a norm that takes an entire, concrete individuality into consideration, as an individual, unique, norm. The individual is the measure of its own normality. When normal is measured in terms of selection, transmission, processing, and storage of information, aligned with the use value of a machine that transforms information, abnormal is only considered in terms of the failure of this use value and no room is left for extra-machinic variability of an individual norm. To note, although I have avoided discussions of the influential philosophy of Jürgen Habermas and his discussion of social norms - very much developed in response to the technicism he saw operative in 1960s political discourse - it is worth understanding that neither does his consideration of ethical norms solve the dilemma. For Habermas, a norm must satisfy the condition that "all affected can accept the consequences and side effects its *general* observance can be anticipated to have for the satisfaction of *everyone's* interests."[29] In other words, for a claim to be recognized as valid, all affected by it must accept it freely. Particularities are irrelevant to a universal norm. As such, it refuses concern with alterity of the individual, both in regards to another and within herself or himself.

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[27] Karl Jaspers, *Allgemeine Psychopathologie* (Berlin: Springer, 1923).
[28] Kurt Goldstein, *The Organism* (New York: Zone Books, 1995), 326.
[29] Jürgen Habermas, *Moral Consciousness and Communicative Action* (Cambridge: MIT Press, 1990), 65.

Although 1967 is the final year considered in depth, by no means should this imply the Design Method movement's termination point. Several groups propelled forth from the subjects explored during the Design Methods movement. For example, in 1966 in the UK the Design Research Society (DRS) was founded. The first members were almost entirely participants of the 1962 Conference on Design Methods, discussed in Chapter Four. Its first statement of purpose was to promote "the study of and research into the process of designing in all its many fields."[30] The DRS began a series of single day conferences and a quarterly newsletter. For its first ten years its chair was held by those active in the Design Methods Movement: John Page, William Gosling, J. Christopher Jones, and Sydney Gregory.

In the US, the Design Methods Group (DMG) was founded in 1967. By 1969 its membership was over 600 across 18 countries. One of its earliest statements of purpose purported: "we focus upon the process of design rather than limiting our concern to areas in which a physical product must be the outcome."[31] It published *The Design Methods Group Newsletter* under joint sponsorship by the College of Environmental Design, University of California, Berkeley - where Christopher Alexander was then teaching - and the School of Architecture, Washington University, St. Louis, Missouri. In the mid 1970s the DRS and DMG joined to publish the journal *Design Research and Methods* before the DRS began publishing its own journal, Design Studies, still active today, in 1979. Additionally, the Environment Design Research Association (EDRA) was founded in 1968. Quite beholden to the research of William Ittelson in its early days (see Chapter Seven), it currently manifests a significant presence through sponsoring multiple publications and conferences.

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[30] http://www.designresearchsociety.org/joomla/content/view/13/27/. Accessed September 10, 2007.
[31] Thomas L. Thomson, "Design Methods Group," *Management Science* 15, no. 8 (Apr., 1969), B359.

This dissertation examines how computer-related media, such as cybernetics, information theory and computers, reconfigured the politics of culture and nature in architectural, engineering, urban planning, product design education and practice. Ranging from the endeavors of funding surrounding an city planning research center in Cambridge, Massachusetts to conferences concerning, architecture, engineering, and product design in the UK, I take, from Friedrich Kittler, that technologically possible manipulations condition what can become a discourse: Socio-cultural constituents can only be addressed if statements' contents are structured according to the discursive regulation of the technology through which the statement circulates. Furthermore, I refer to computer related media because whereas medium form a closed loop between material and its aesthetic product, media provides an open relation between humans and technology.

I structure the discussion around two strains. One thread concerns how computer-related media configured a re-conceptualization of nature and culture in these design disciplines. Nature and socio-culture were reconfigured in terms of the use value of information technologies, a change made possible by drawing from emerging computer-related media. A second thread examines how psychology and psychoanalytic understandings were reworked for design through the lens of computer related technologies. This puts into question a line between the natural and the normative relative to abnormality and deviation, which is relevant because to violate the norms of nature has been considered unhealthy, amoral, and even illegal.

FIGURES

THE CHRISTIAN SCIENCE MONITOR, BOSTON, SATURDAY, JANUARY 11, 1958

MIT Inaugurates City-Plan Center

By Richard L. England

Cambridge, Mass.

A program of international mutual aid in city planning is getting under way at the new Center for Urban and Regional Studies at the Massachusetts Institute of Technology.

Planning Problem Near Top

Transportation Key Sought

Reaction Investigated

Faculty Help Needed

MIT Planners Discuss New Center

Figure 2.1. Article announcing formation of MIT Center for Urban and Regional Studies. From Richard L. England, "MIT Inaugurates City-Plan Center," *Christian Science Monitor*, January 11, 1958.

Figure 2.2. The IBM 704 Data Processing System. From http://www-03.ibm.com/ibm/history/exhibits/mainframe/mainframe_PP704.html. Accessed Septermber 24, 2006.

Figure 2.3 Planner Martin Meyerson. From University Archives and Records Center, University of Pennsylvania. http://www.archives.upenn.edu/histy/features/uplans/meyerson.html. Accessed January 10, 2008.

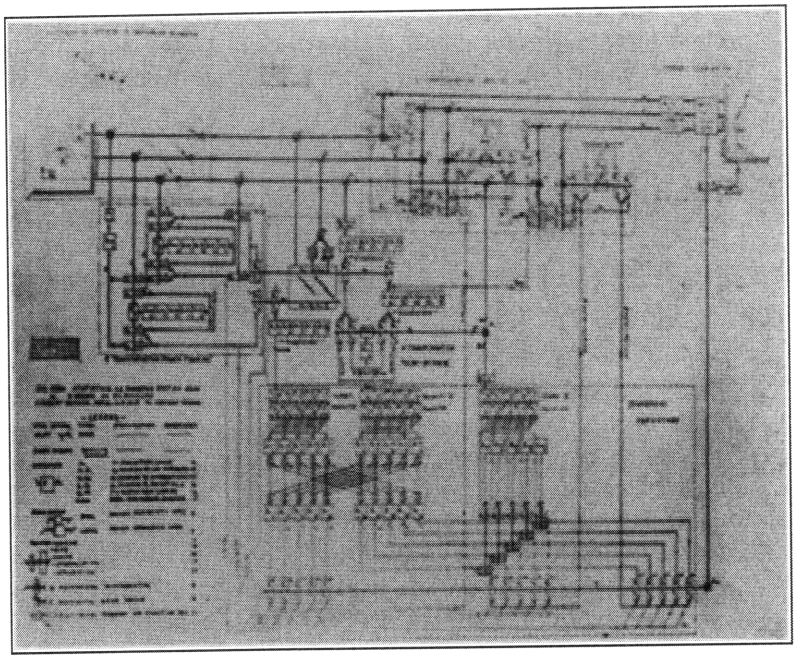


Figure 2.4. Wiring circuit for Wiener's antiaircraft predictor. From Norbert Wiener to D. I. C. 5980 A. A. Directors, "Summary Report for Demonstration," 10 June 1942, Record Group 227, Office of Science and Research Development, National Defense Research Committee Contractors' Technical Reports, Division 7, MIT, NDCrc-83, National Archives, Library of Congress, Washington, D. C.

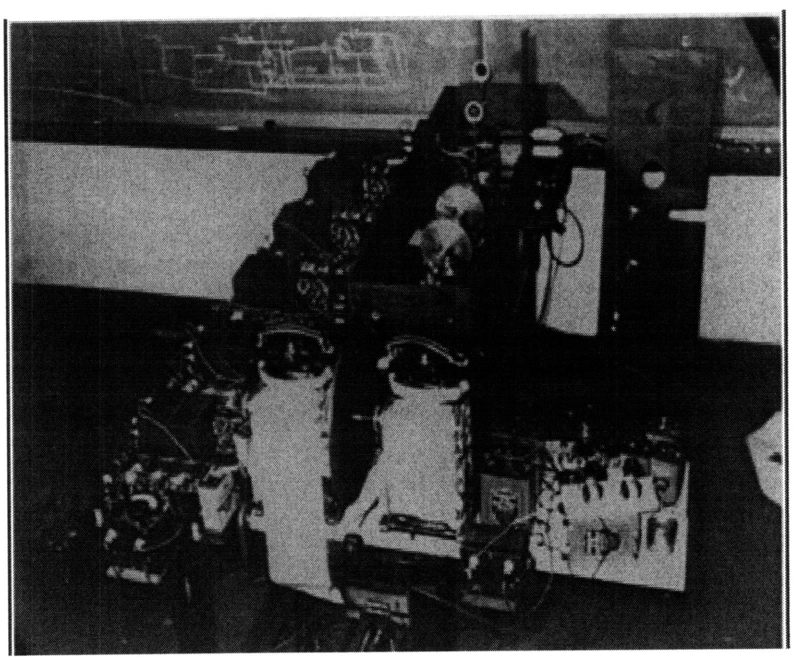


Figure 2.5. The antiaircraft predictor. From Wiener to D. I. C. 5980 A A Directors, "Summary Report for Demonstration."

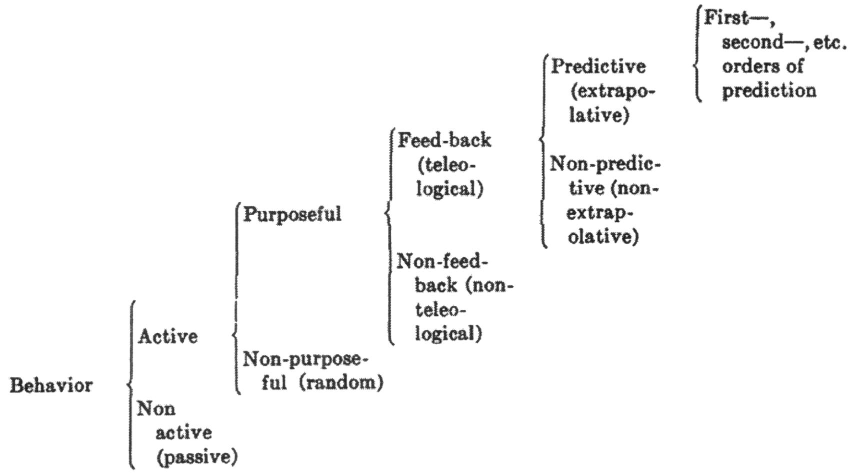


Figure 2.6. Forms of behavior in Arturo Rosenblueth, Norbert Wiener and Julian Bigelow, "Behavior, Purpose and Teleology," *Philosophy of Science* 10, no. 1. (Jan., 1943): 21.

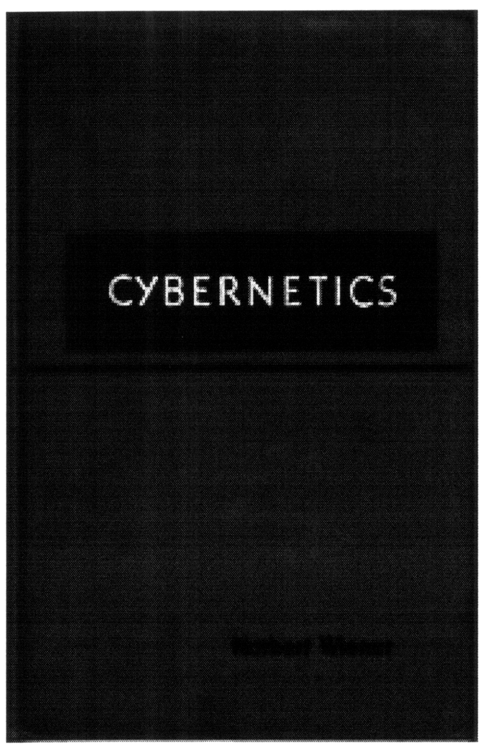


Figure 2.7. Cover of 1948 edition of Norbert Wiener, *Cybernetics; or, Control and Communication in the Animal and the Machine* (Cambridge, MA: Technology Press, 1948).

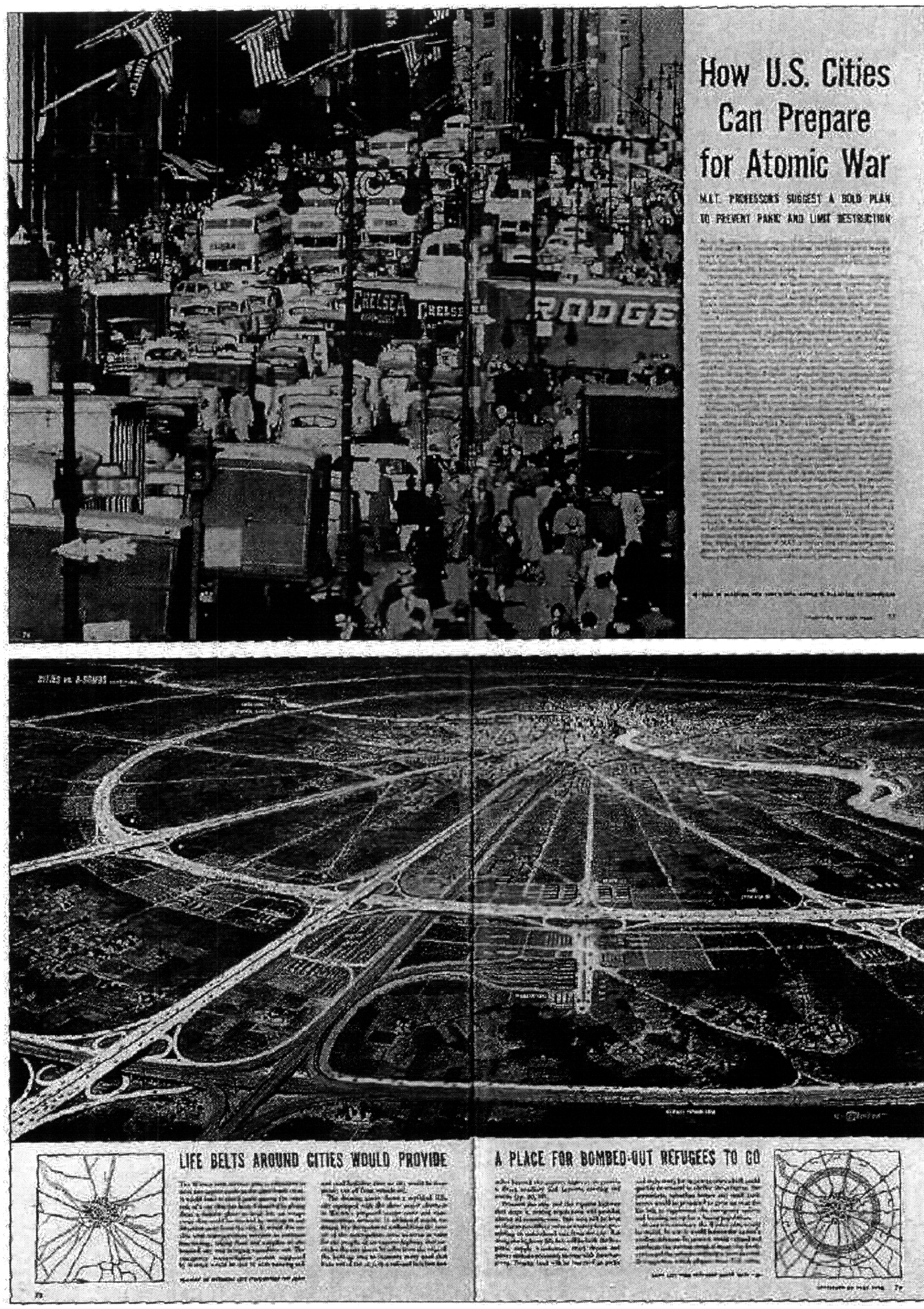
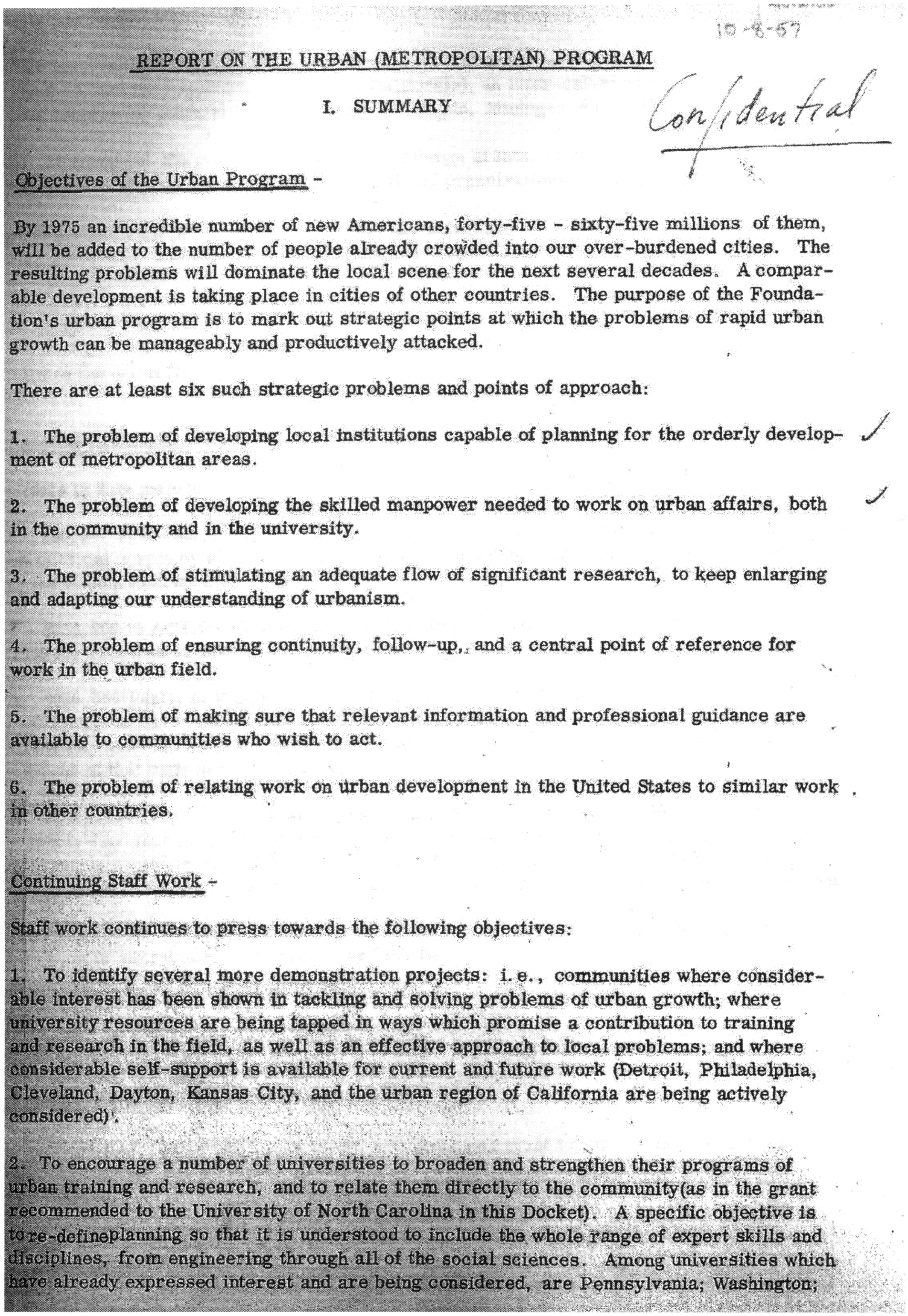


Figure 2.8. Pages from "How U.S. Cities Can Prepare for Atomic War," *Life* (December 18, 1950): 76-79.



10-8-57

REPORT ON THE URBAN (METROPOLITAN) PROGRAM

Confidential

I. SUMMARY

Objectives of the Urban Program -

By 1975 an incredible number of new Americans, forty-five - sixty-five millions of them, will be added to the number of people already crowded into our over-burdened cities. The resulting problems will dominate the local scene for the next several decades. A comparable development is taking place in cities of other countries. The purpose of the Foundation's urban program is to mark out strategic points at which the problems of rapid urban growth can be manageably and productively attacked.

There are at least six such strategic problems and points of approach:

1. The problem of developing local institutions capable of planning for the orderly development of metropolitan areas.

2. The problem of developing the skilled manpower needed to work on urban affairs, both in the community and in the university.

3. The problem of stimulating an adequate flow of significant research, to keep enlarging and adapting our understanding of urbanism.

4. The problem of ensuring continuity, follow-up, and a central point of reference for work in the urban field.

5. The problem of making sure that relevant information and professional guidance are available to communities who wish to act.

6. The problem of relating work on urban development in the United States to similar work in other countries.

Continuing Staff Work -

Staff work continues to press towards the following objectives:

1. To identify several more demonstration projects: i.e., communities where considerable interest has been shown in tackling and solving problems of urban growth; where university resources are being tapped in ways which promise a contribution to training and research in the field, as well as an effective approach to local problems; and where considerable self-support is available for current and future work (Detroit, Philadelphia, Cleveland, Dayton, Kansas City, and the urban region of California are being actively considered).

2. To encourage a number of universities to broaden and strengthen their programs of urban training and research, and to relate them directly to the community(as in the grant recommended to the University of North Carolina in this Docket). A specific objective is to re-defineplanning so that it is understood to include the whole range of expert skills and disciplines, from engineering through all of the social sciences. Among universities which have already expressed interest and are being considered, are Pennsylvania; Washington;

Figure 2.9. Page from the Ford Foundation's "Report of the Urban (Metropolitan) Program," Oct 8, 1957, 1, Box 6, Folder "OK AC 400 B.6," AC 400, IASC

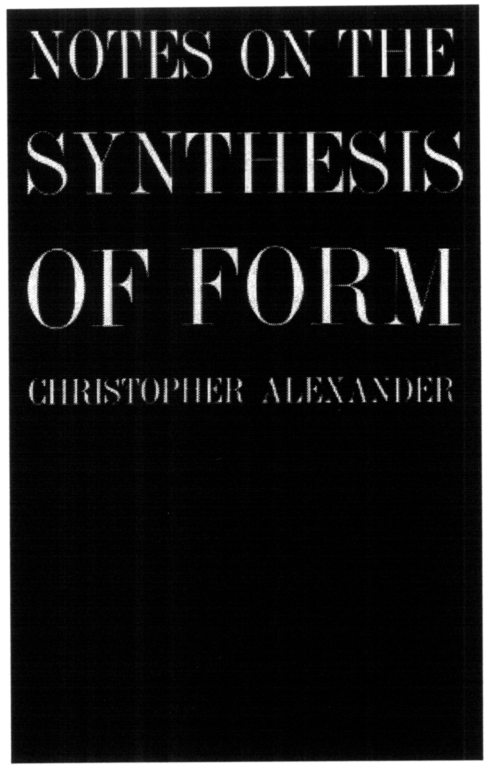


Figure 3.1 1964 edition of Chistopher Alexander, *Notes on the Synthesis of Form* (Cambridge, MA: Harvard University Press, 1964).

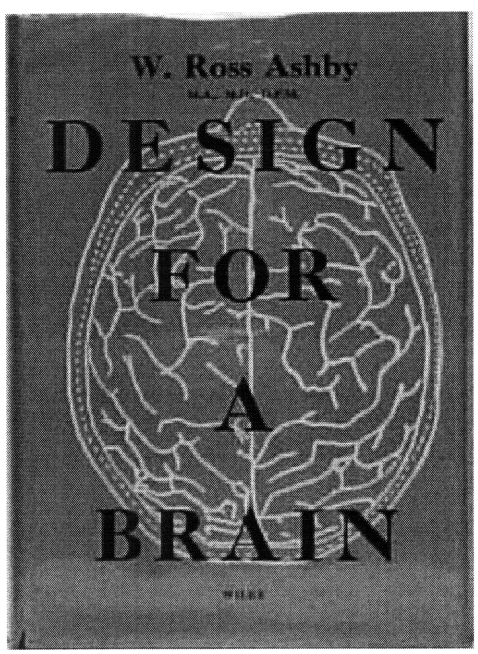


Figure 3.2. 1956 edition of W. Ross Ashby, *Design for a Brain* (New York: Wiley, 1956).

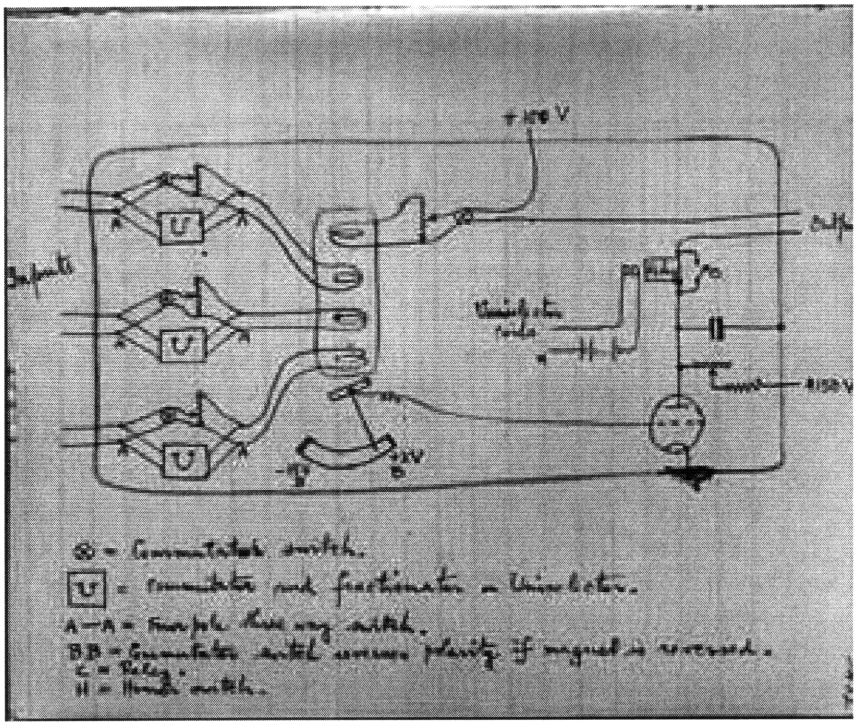


Figure 3.3. Diagram of the homeostat. From Ashby's notebooks. http://www.zone88.plus.com/homeostat.htm. Accessed September 30, 2006.

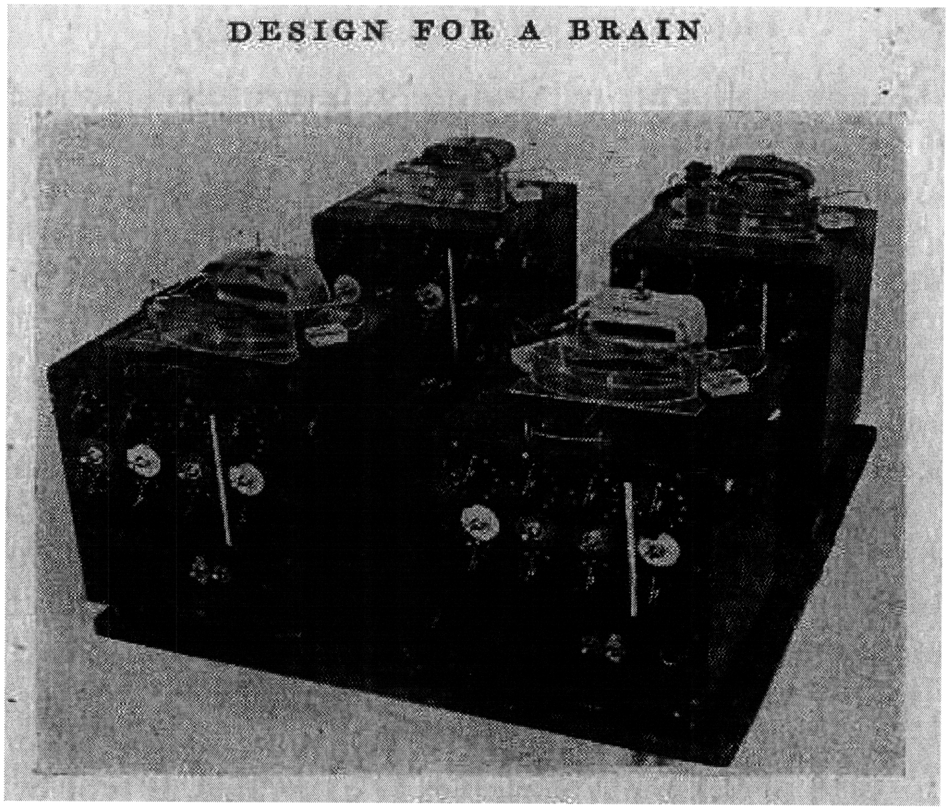


Figure 3.4 The homeostat. From W. Ross Ashby, *Design for a Brain* (New York: Wiley, 1954), 76.

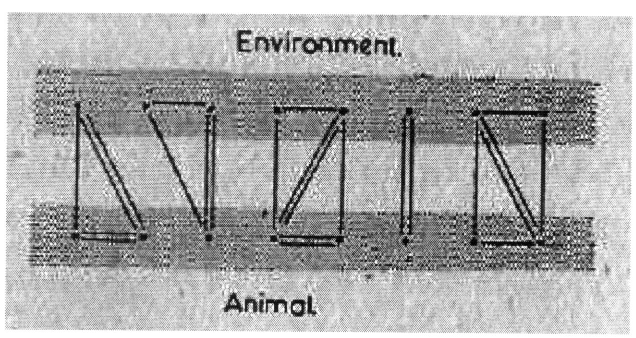


Figure 3.5. Diagrammatic representation of an animal with eight main variables interacting with its environment as five independent subsystems. From W. Ross Ashby, *Design for a Brain*, 89.

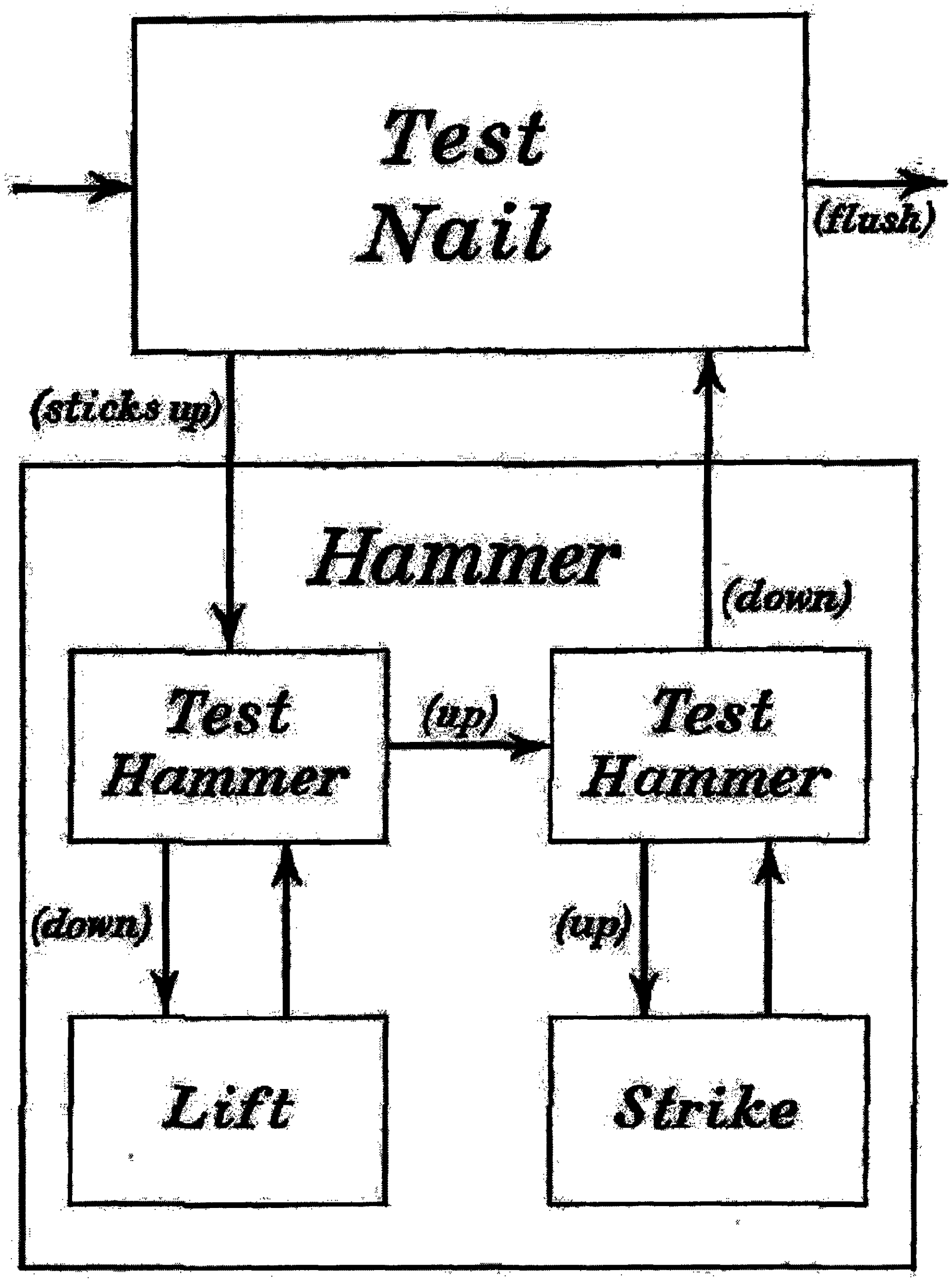


Figure 3.6. A TOTE unit hierarchical plan for hammering a nail. From George Miller, Eugene Galanter, and Karl H. Pribram, *Plans and the Structure of Behavior* (New York: Holt, Rinehart and Winston, 1960), 12.

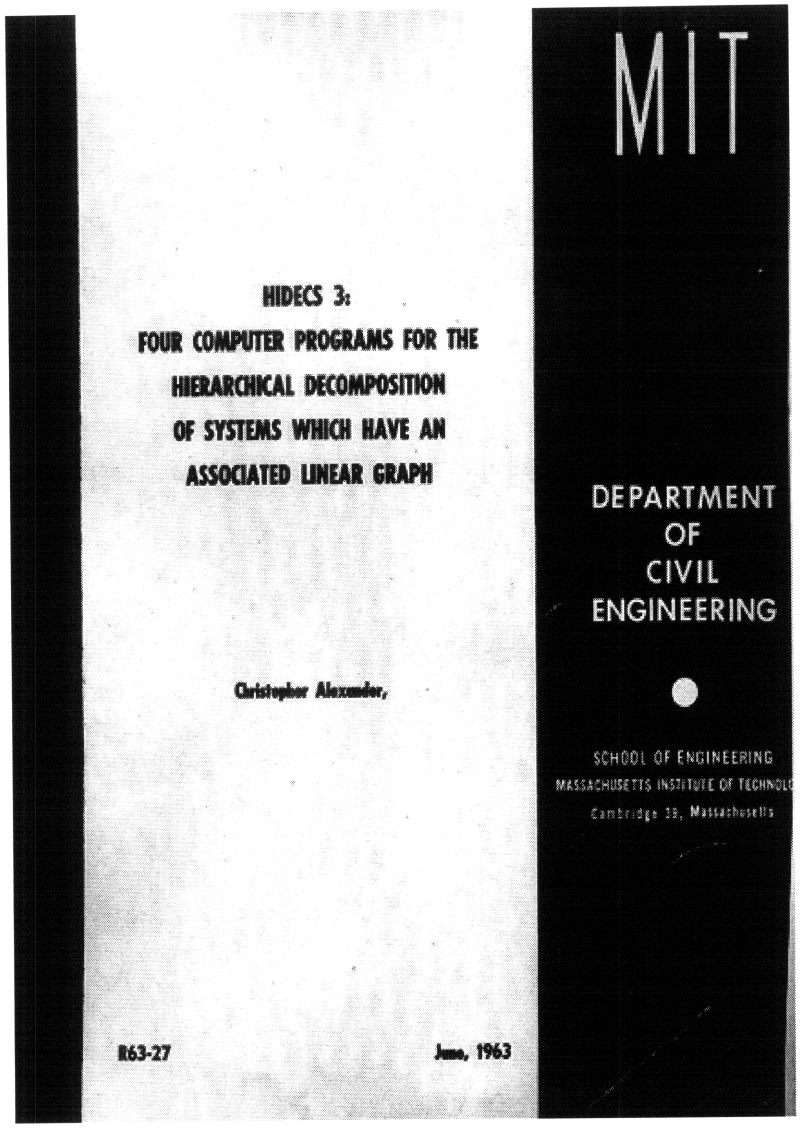


Figure 3.7 Cover of *HIDECS 3*. From Christopher Alexander, *HIDECS 3: Four Computer Programs for the Hierarchical Decomposition of Systems which have an Associated Linear Graph* (Cambrige, MA: Department of Civil Engineering, 1963).

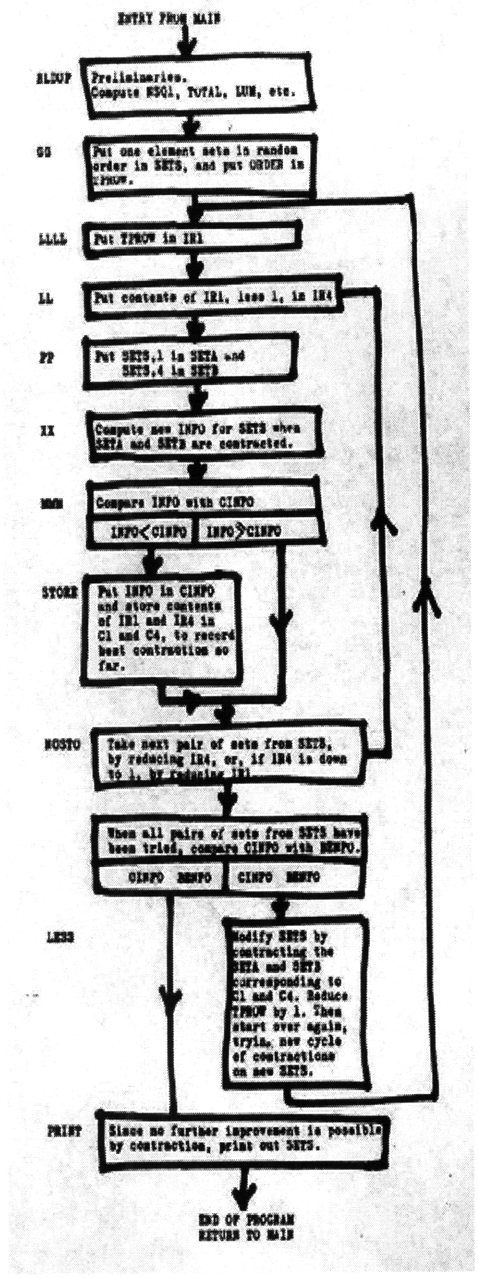


Figure 3.8. BLDUP program. Christopher Alexander, *HIDECS 3*, 12.

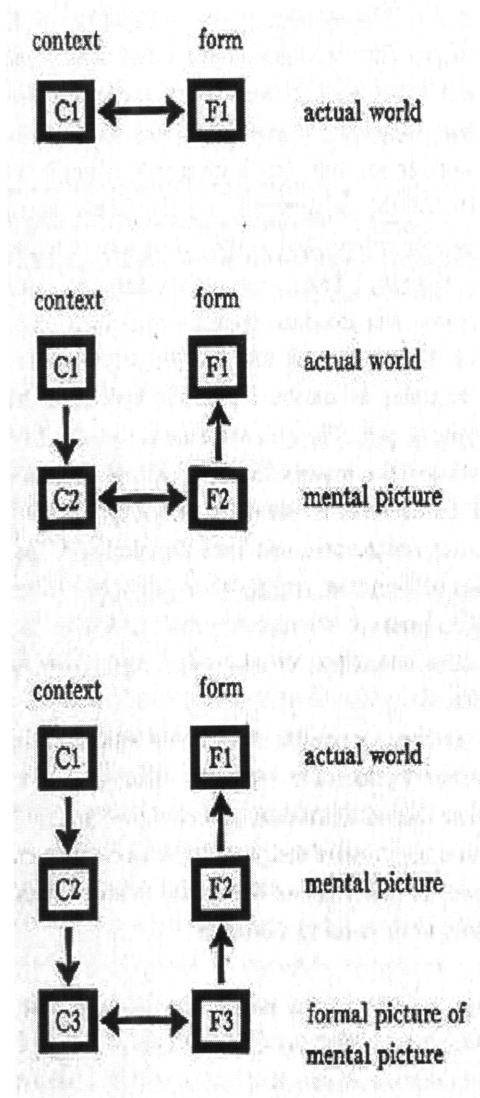


Figure 3.9. Alexander's depiction of "unselfconscious," "selfconscious" and his revised design processes, top to bottom. Christopher Alexander, *Notes*, 76.

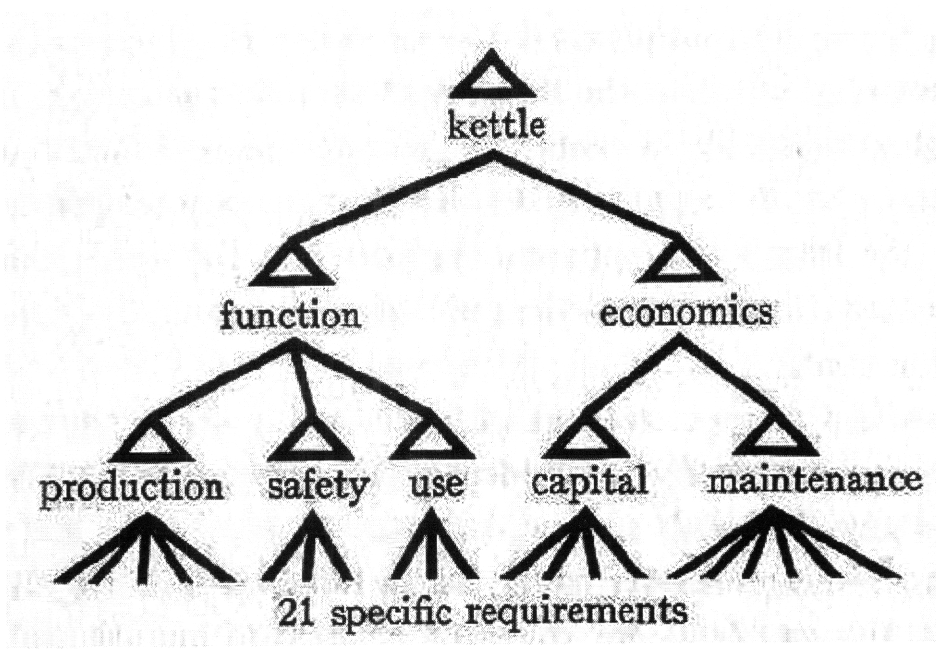


Figure 3.10. Hierarchical decomposition of sets. From Christopher Alexander, *Notes*, 62.

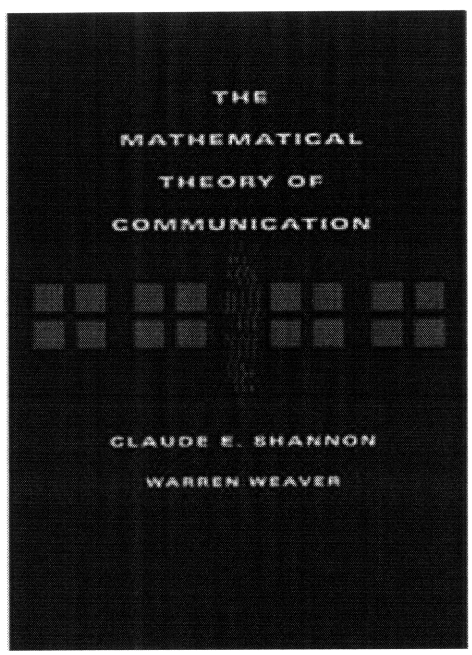


Figure 3.11. Cover of Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Chicago: University of Illinois Press, 1963).

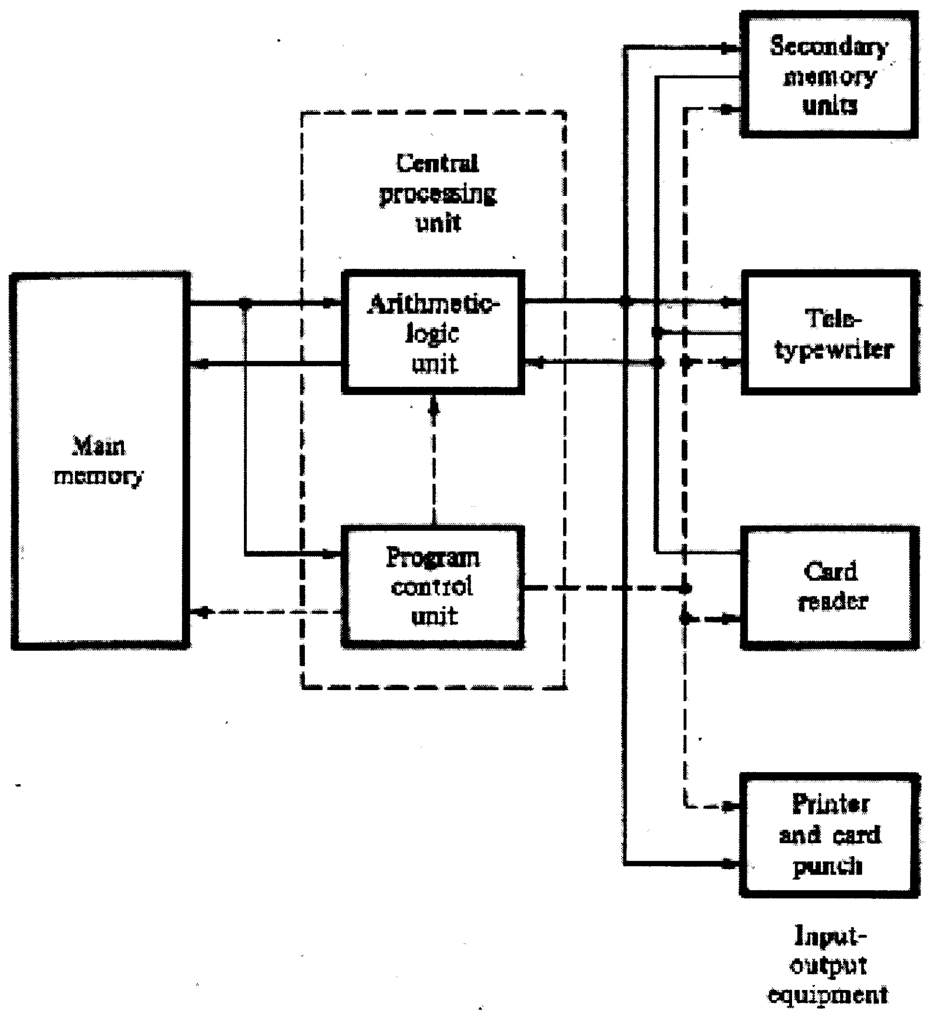


Figure 3.12. Architecture of IBM 704.

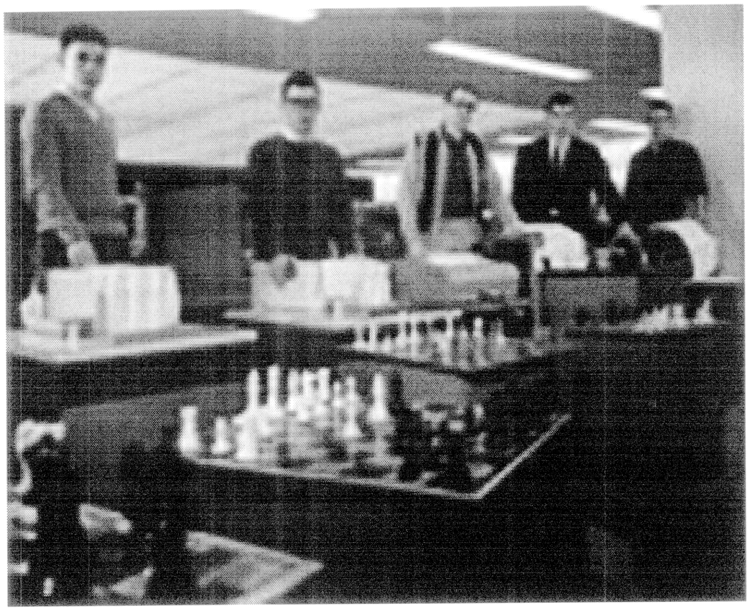


Figure 3.13. MIT Computation Center, early 1960s.

Figure 4.1. Home of the Applied Psychology Unit since 1952. From L. A. Reynolds and E. M. Tansey, "The MRC Applied Psychology Unit," *Wellcome Witness to Twentieth Century Medicine* Vol. 16: 12. http://www.ucl.ac.uk/histmed/PDFS/Publications/Witness/wit16.pdf. Accessed January 23, 2008.

Figure 4.2. Kenneth J. W. Craik (1914-1945). From L. A. Reynolds and E. M. Tansey, "The MRC Applied Psychology Unit," *Wellcome Witness to Twentieth Century Medicine* Vol. 16: 12. http://www.ucl.ac.uk/histmed/PDFS/Publications/Witness/wit16.pdf. Accessed January 23, 2008.

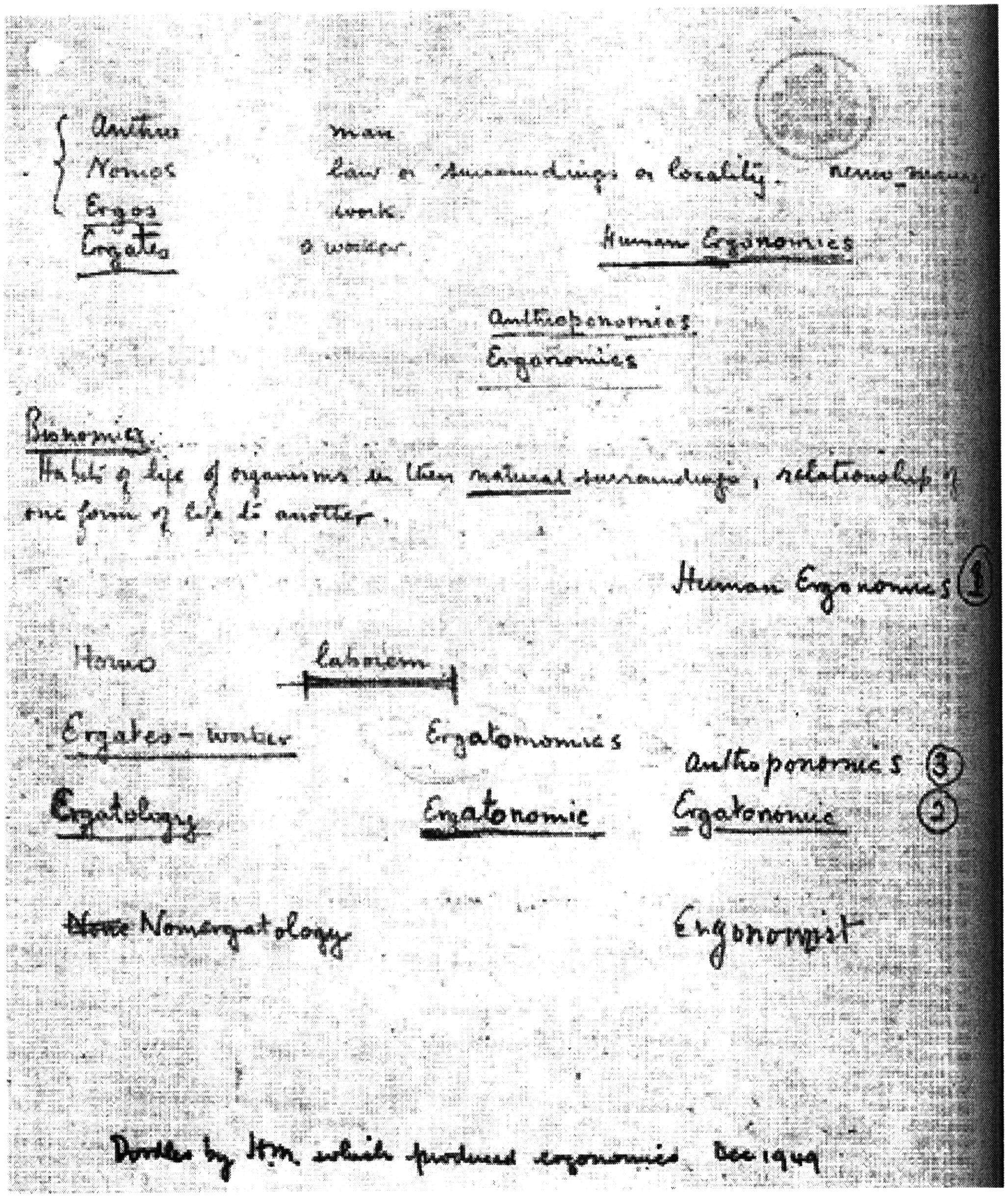


Figure 4.3. Sheet upon which K.F.H. Murrell determined the word "ergonomics." From O. G. Edholm and K.F.H. Murrell, "History of the Ergonomics Research Society," *Ergonomics* 1, no. 1 (November 1957): 108.

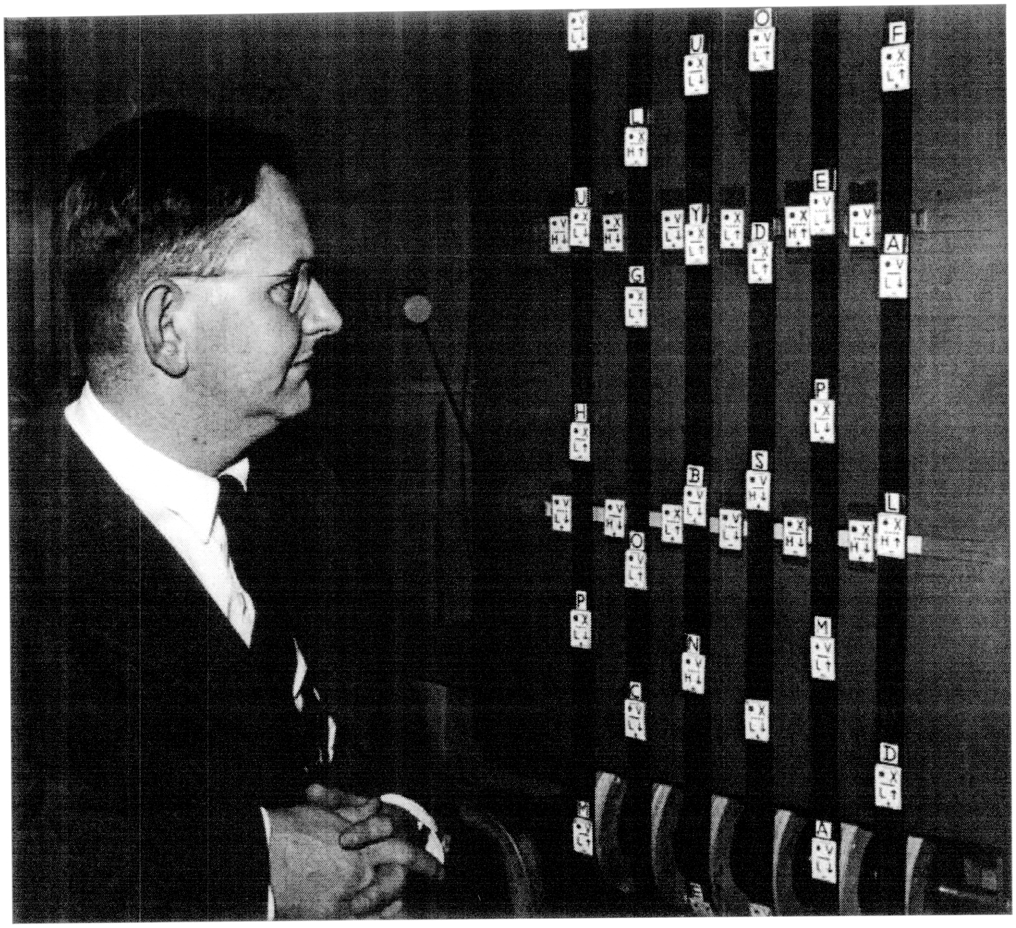


Figure 4.4. Norman H. Mackworth, head of Applied Psychology Unit and founding member of the Ergonomics Research Society. From L. A. Reynolds and E. M. Tansey, "The MRC Applied Psychology Unit," *Wellcome Witness to Twentieth Century Medicine* Vol. 16: 4. http://www.ucl.ac.uk/histmed/PDFS/Publications/Witness/wit16.pdf. Accessed January 23, 2008.

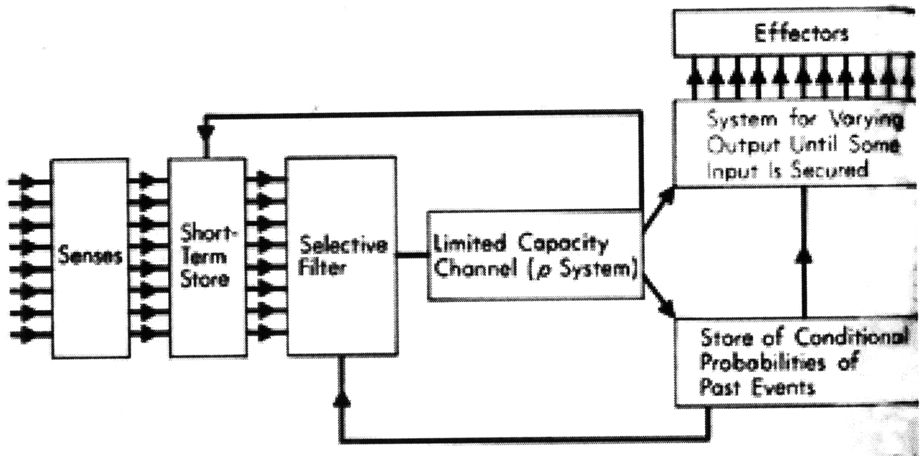


Figure 4.5. Donald Broadbent's filter theory of selection and memory. From Donald Broadbent, *Perception and Communication* (Elmsford, NY: Pergamon Press, 1958), 158.

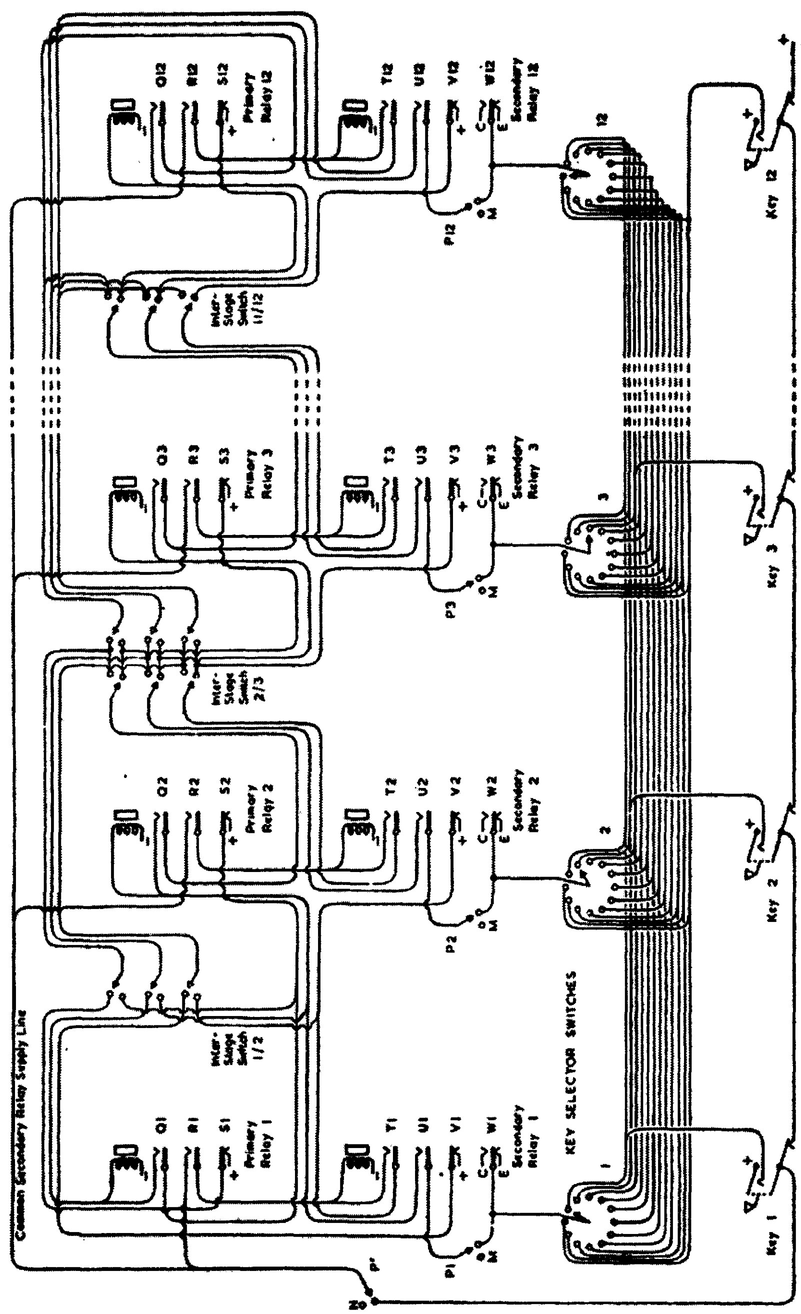


Figure 4.6. Diagram of main circuit in A.T. Welford's apparatus for use in studying serial performance. From A.T. Welford, "An Apparatus for Use in Studying Serial Performance," *The American Journal of Psychology* 65, no. 1. (Jan., 1952): 93.

Figure 4.7. W.H. Mayall (1923-1998). From University of Brighton Design Archives. http://www.bton.ac.uk/designarchives/whmayall/index.html. Accessed November 20, 2007.

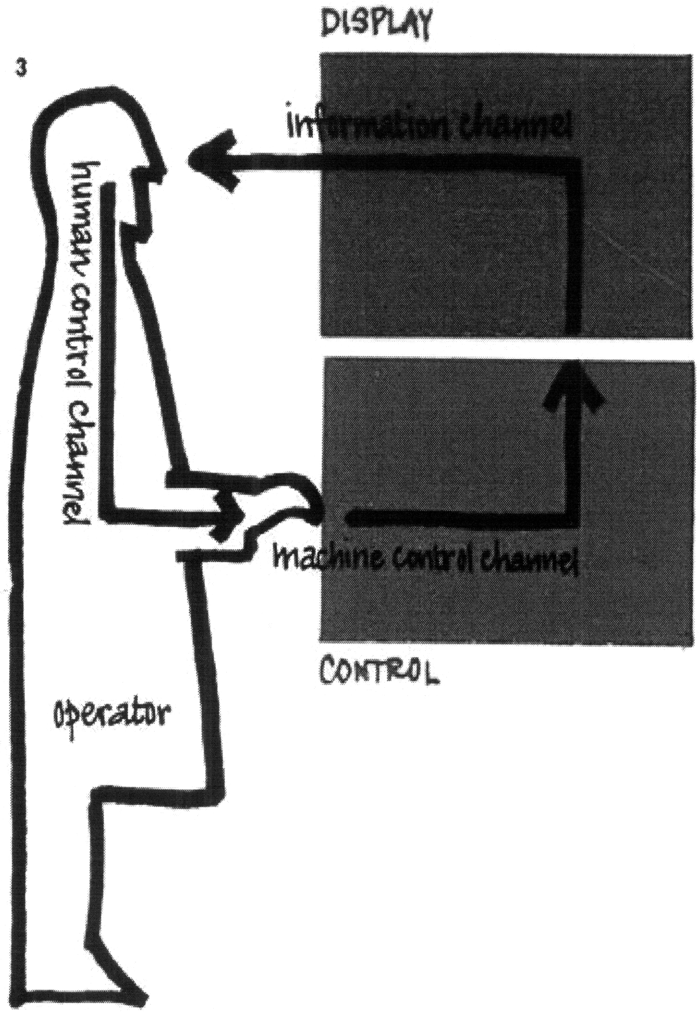


Figure 4.8. Control-loop concept. From W. H. Mayall and B. Shackel, "Control-Loop Concept," *Design* 148: 45.

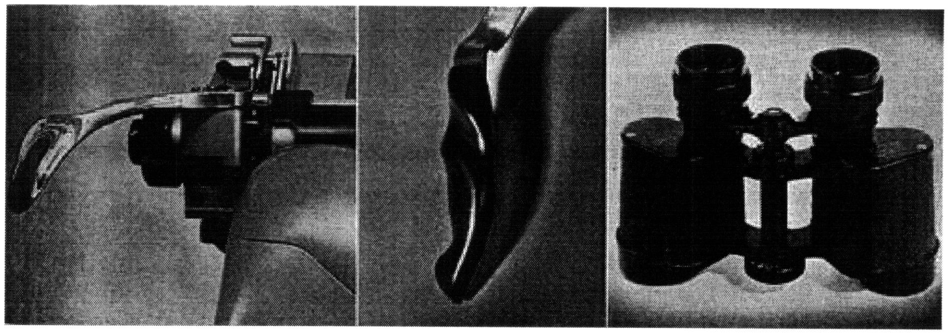


Figure 4.9. Jones' admired forms for input-output devices. From J. Christopher Jones, "Automation and Design: 5," *Design* 110: 47.

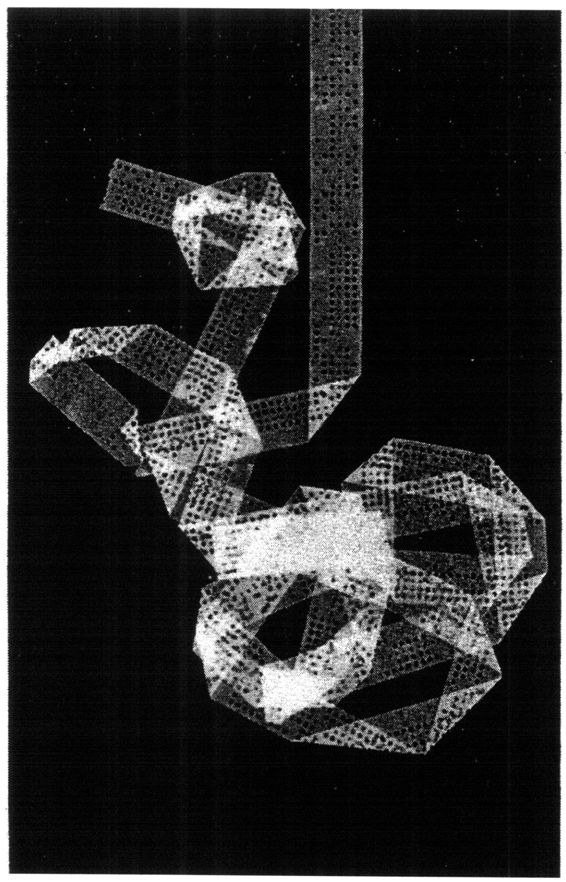


Figure 4.10. Automation's provision for randomness. From J. Christopher Jones, "Automation and Design: 2," *Design* 104: 15.

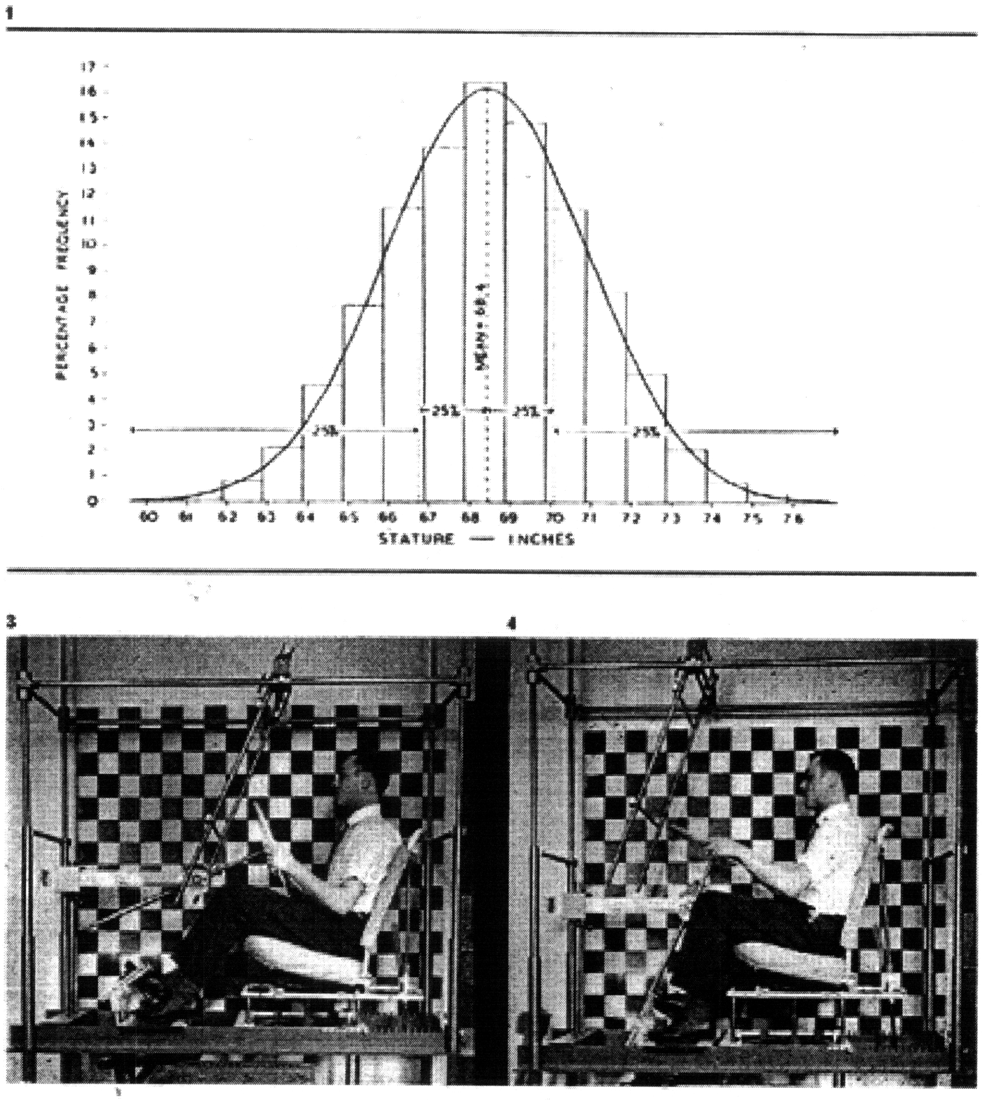


Figure 4.11. Method of Fitting Trials. From J. Christopher Jones, "Fitting for Action: 2," *Design* 135: 43.

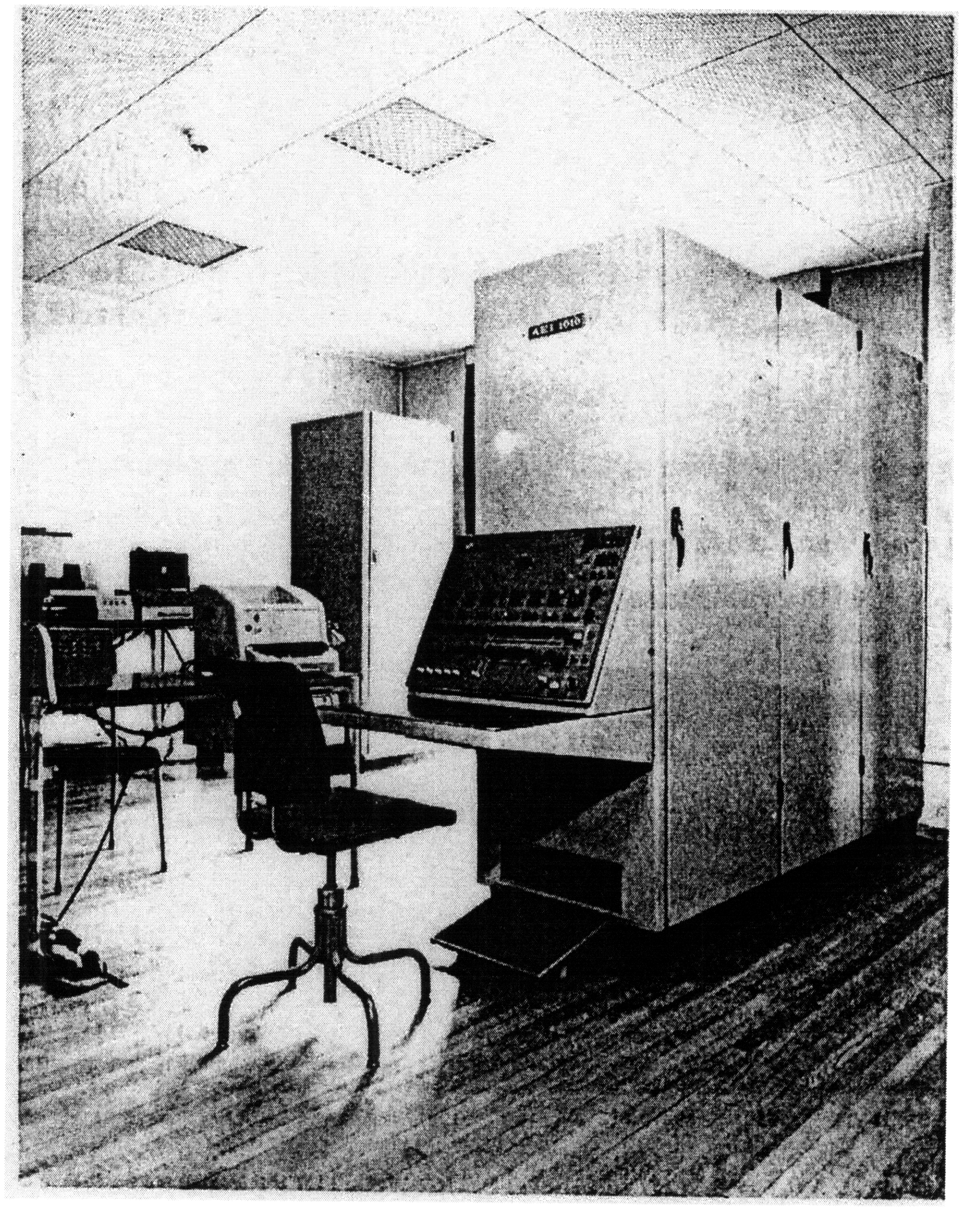


Figure 4.12. AEI 1010. From *AEI Industrial Design Course, Loughborough College of Technology, September 7-9, 1961.* John Christopher Jones Archive, Indiana University, care of Tom Mitchell.

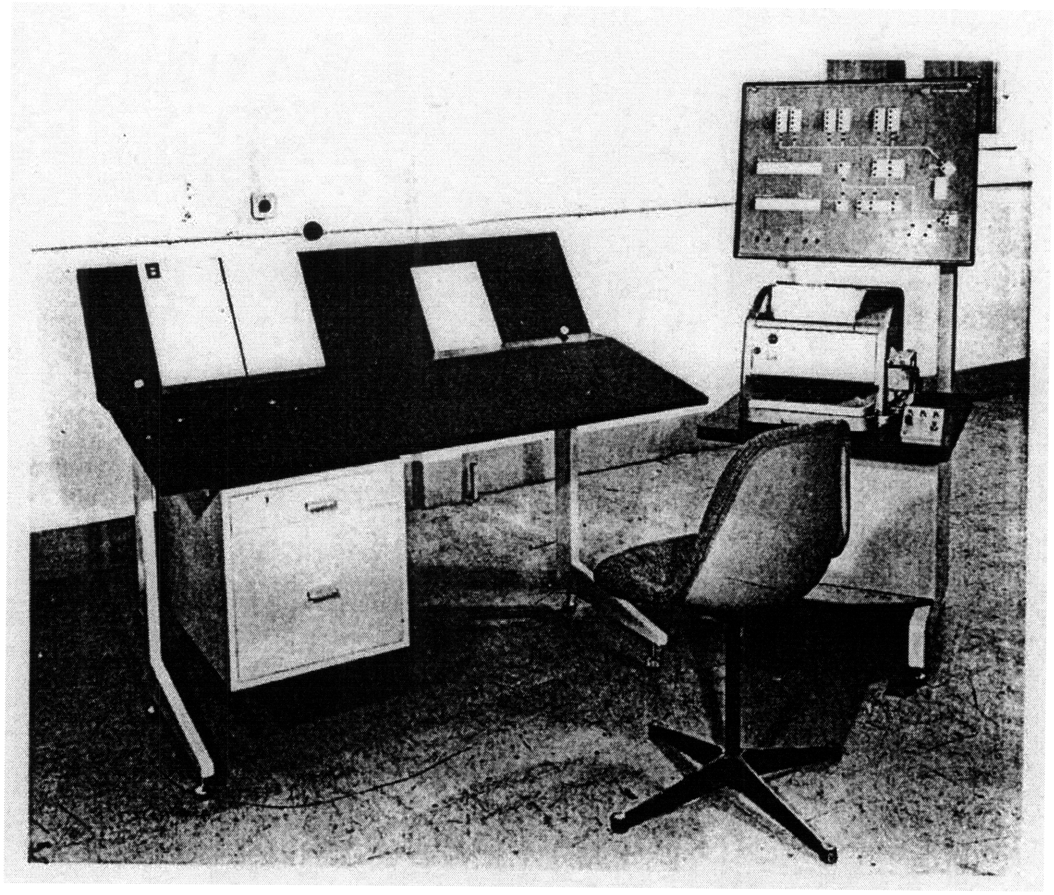


Figure 4.13. AEI 1010 peripherals. From *AEI Industrial Design Course, Loughborough College of Technology, September 7-9, 1961.* John Christopher Jones Archive, Indiana University, care of Tom Mitchell.

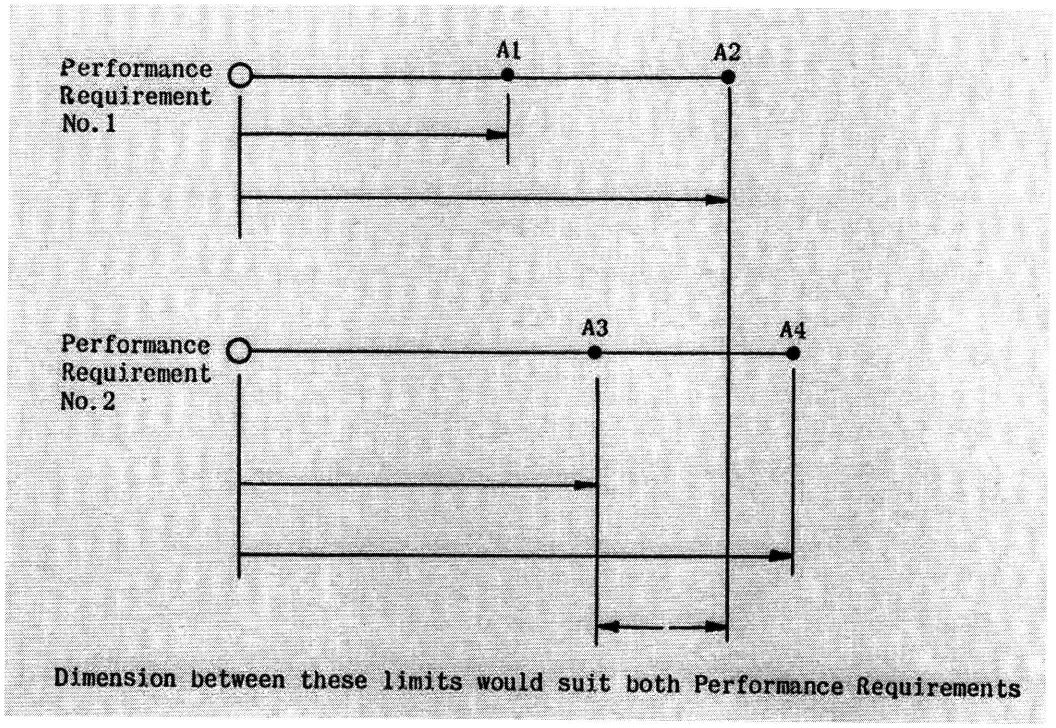


Figure 4.14. Dimensions of sample p-specs. From *AEI Industrial Design Course, Loughborough College of Technology, September 7-9, 1961.* John Christopher Jones Archive, Indiana University, care of Tom Mitchell.

P—SPECS	Sets of compatible partial solutions					
	Set 1	Set 2	Set 3	Set 4	Set 5	
1	P11	P12	P13	P14		
2	P21	P22				
3	P31		P33			
4		P42	P43	P45		

Figure 4.15. P-spec matrix. From J. Christopher Jones, "A Method of Systematic Design," in *Conference on Design Methods* (New York: Macmillan, 1963), 67.

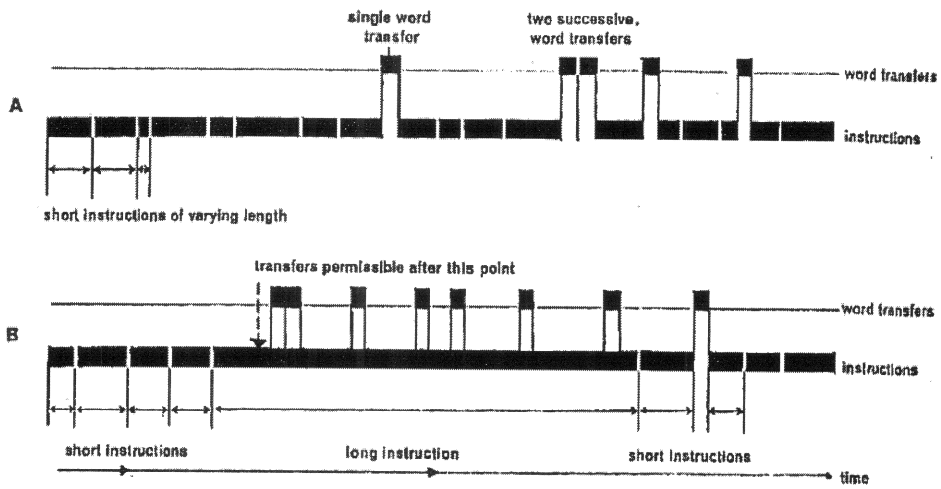


Figure 4.16. AEI 1010 data transfer and instructions. From J.C.Gladman, "AEI 1010: A Computer for Commerce and Industry," *AEI Engineering* (April 1961): 152.

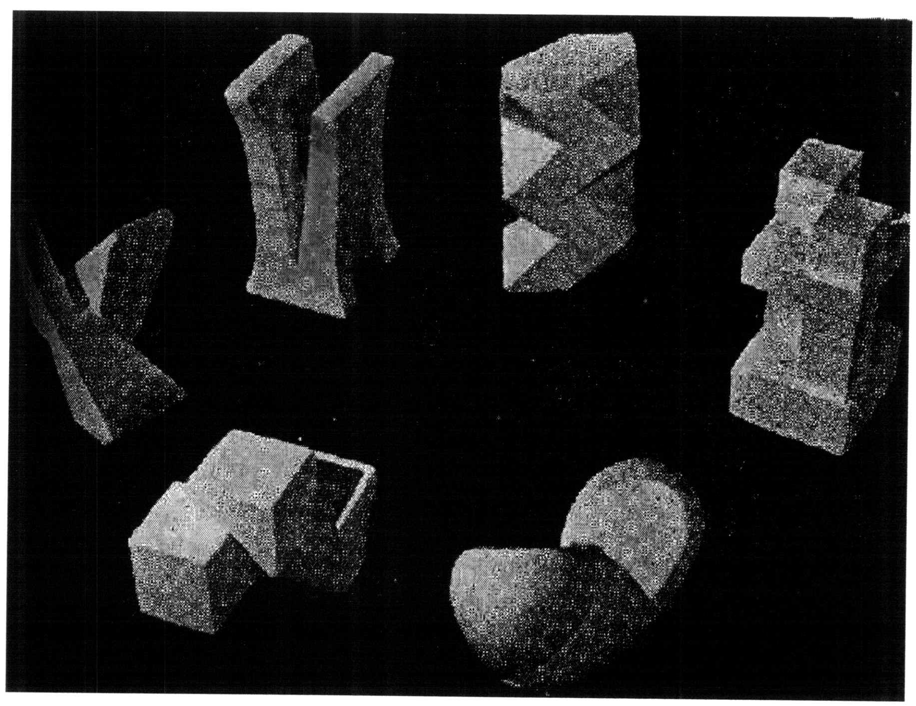
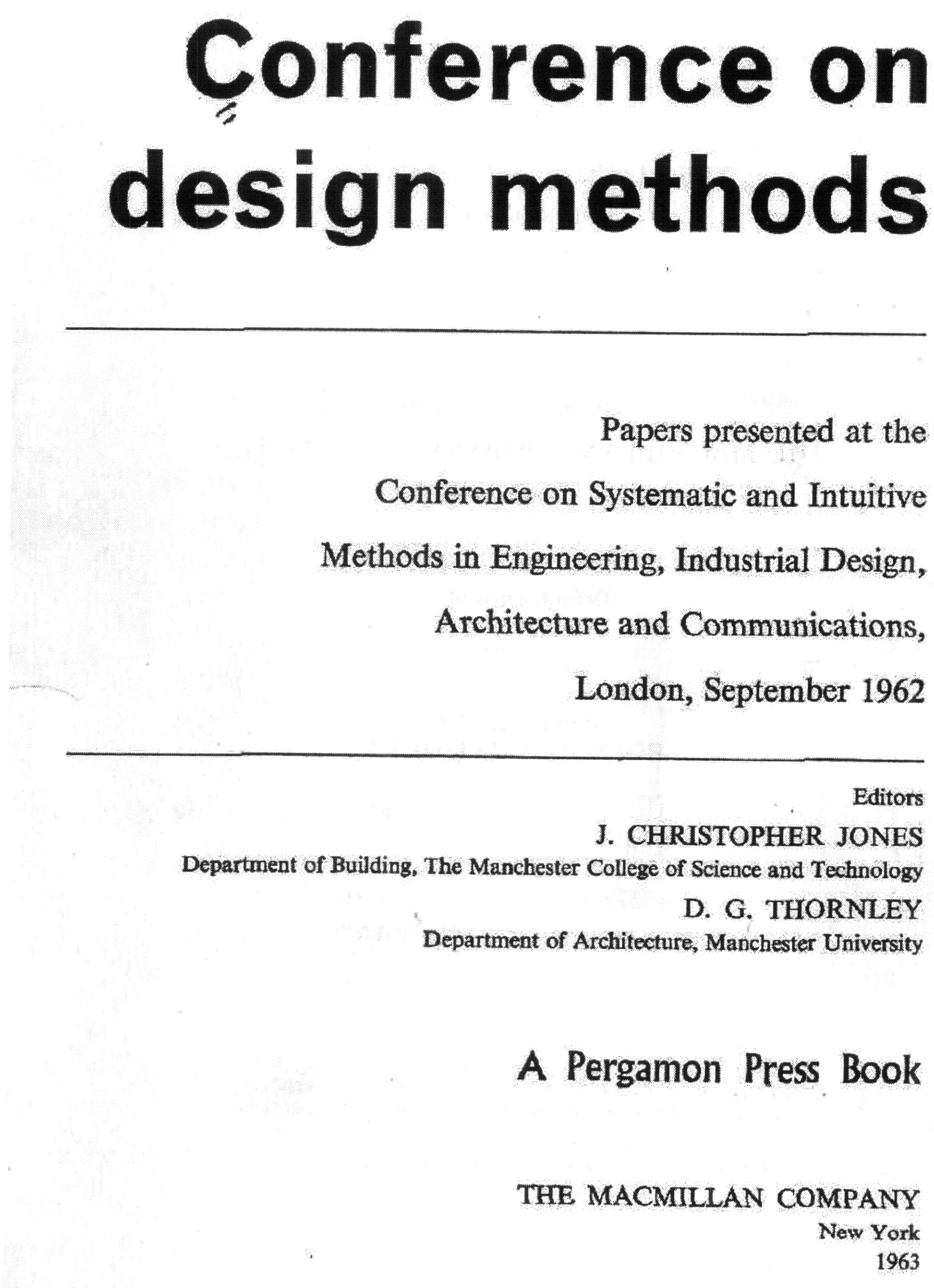


Figure 4.17. Results of AEI's experimental aesthetics course. From W.H. Mayall, "Teaching Engineering Design," in *Conference on the Teaching of Engineering Design* (London: Institution of Engineering Designers, 1964), 283.



Conference on design methods

Papers presented at the
Conference on Systematic and Intuitive
Methods in Engineering, Industrial Design,
Architecture and Communications,
London, September 1962

Editors
J. CHRISTOPHER JONES
Department of Building, The Manchester College of Science and Technology
D. G. THORNLEY
Department of Architecture, Manchester University

A Pergamon Press Book

THE MACMILLAN COMPANY
New York
1963

Figure 4.18. Cover page for published 1962 Conference.

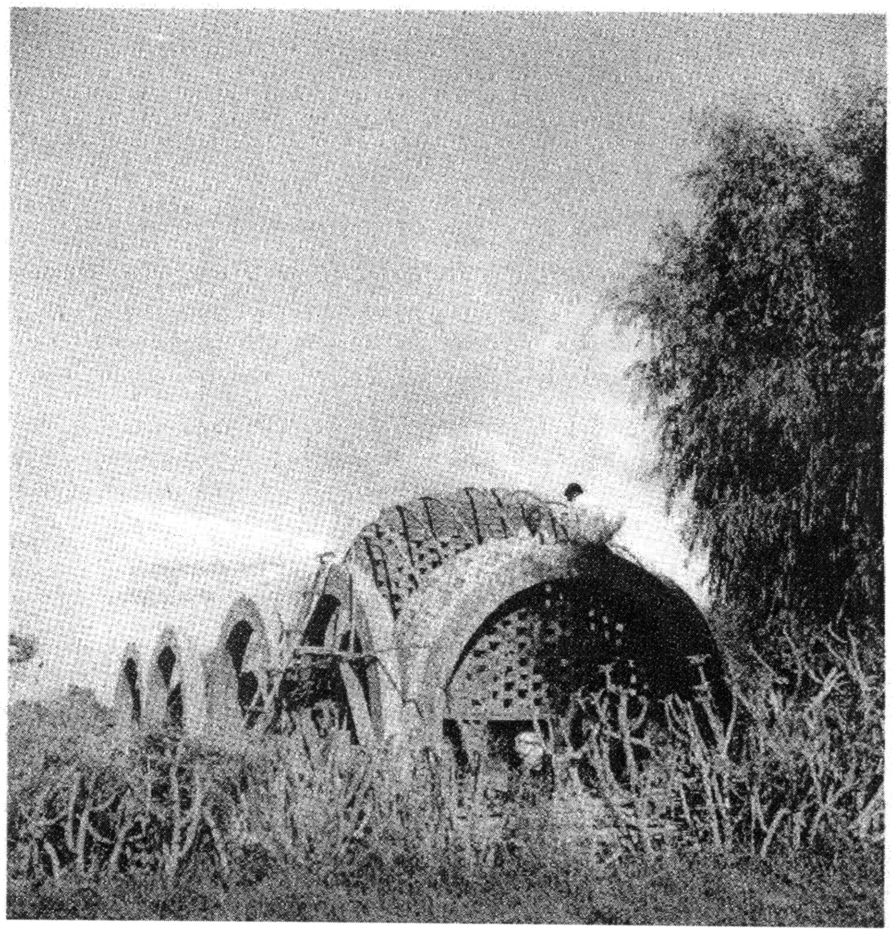


Figure 4.19. School under construction, Bavra, India. From Stephen Grabow, *Christopher Alexander: The Search for a New Paradigm in Architecture* (Boston: Oriel Press, 1983), 245.

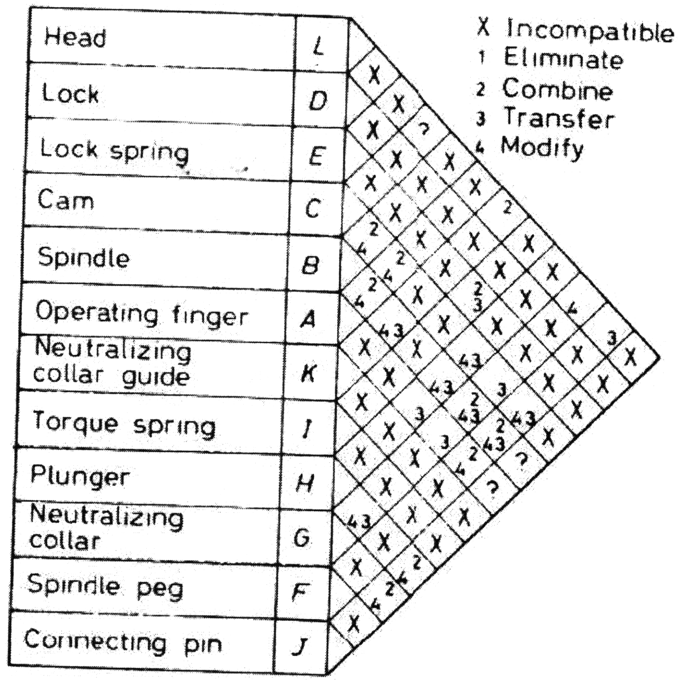


Figure 5.1. Symbols replace drawing in E. Matchett's Fundamental Design Method. From E. Matchett and A. H. Briggs, "Practical Design Based on Method (Fundamental Design Method," in S.A. Gregory, ed., *Symposium on the Design Method* (New York: Plenum Press, 1966), 191.

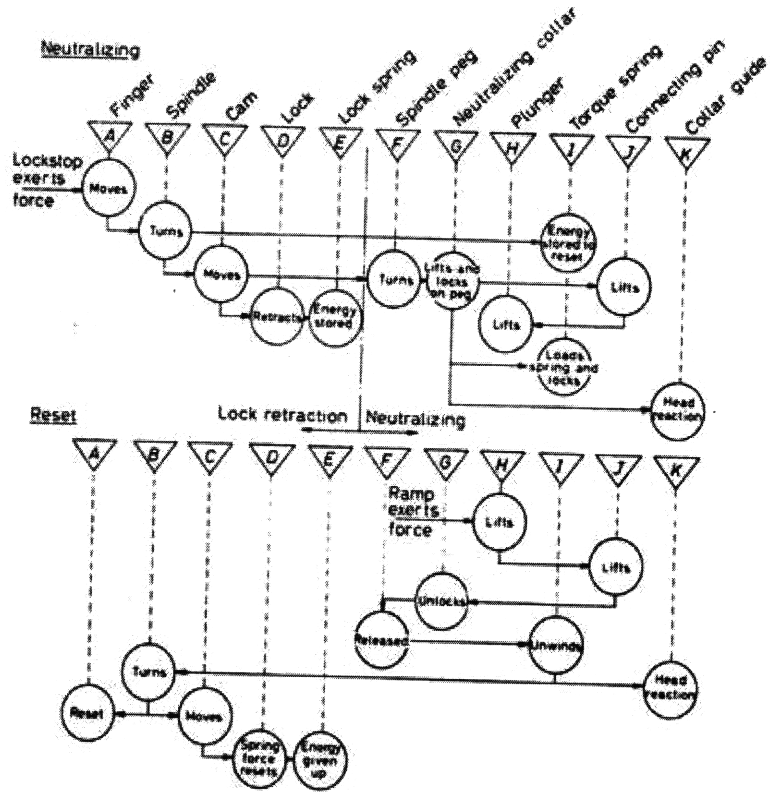


Figure 5.2 In mind as in engineering: E.Matchett's Fundamental Design Method. From E. Matchett and A. H. Briggs, "Practical Design Based on Method (Fundamental Design Method," 192.

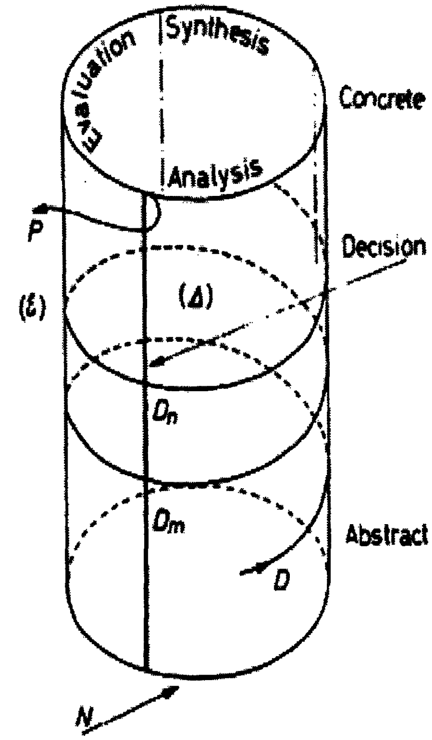


Figure 5.3. Ronald D. Watt's depiction of designing. From Ronald D. Watts, "The Elements of Design," in S.A. Gregory, ed., *Symposium on the Design Method* (New York: Plenum Press, 1966), 85.

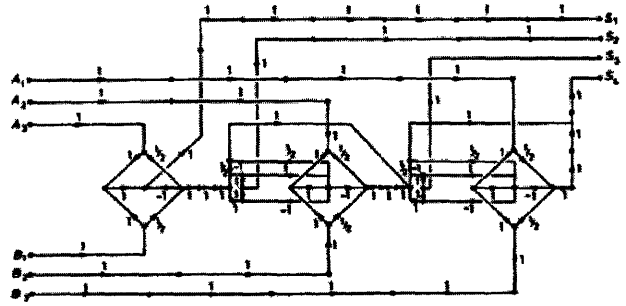


Figure 5.4. A.D. Newman's patterns. From A. D. Newman, "Patterns," in S.A. Gregory, ed., *Symposium on the Design Method* (New York: Plenum Press, 1966), 106.

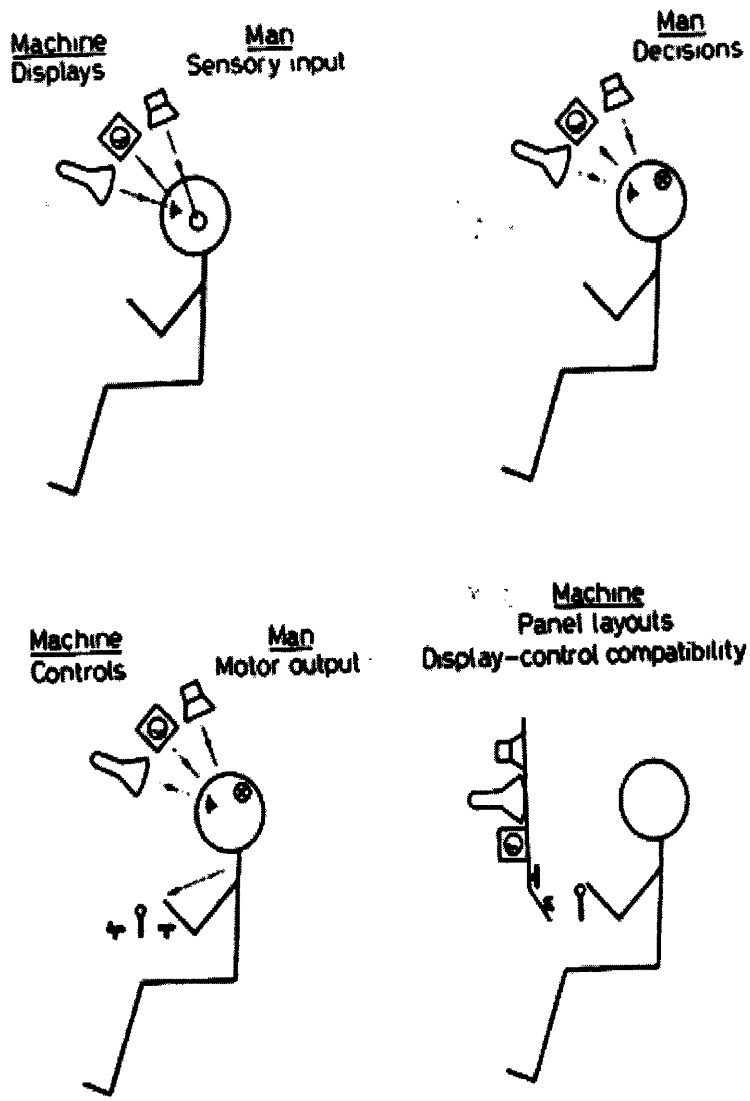


Figure 5.5. Brian Shackel's human-machine interaction. From Brian Shackel, "Ergonomics and Design," in S.A. Gregory, ed., *Symposium on the Design Method* (New York: Plenum Press, 1966), 54.

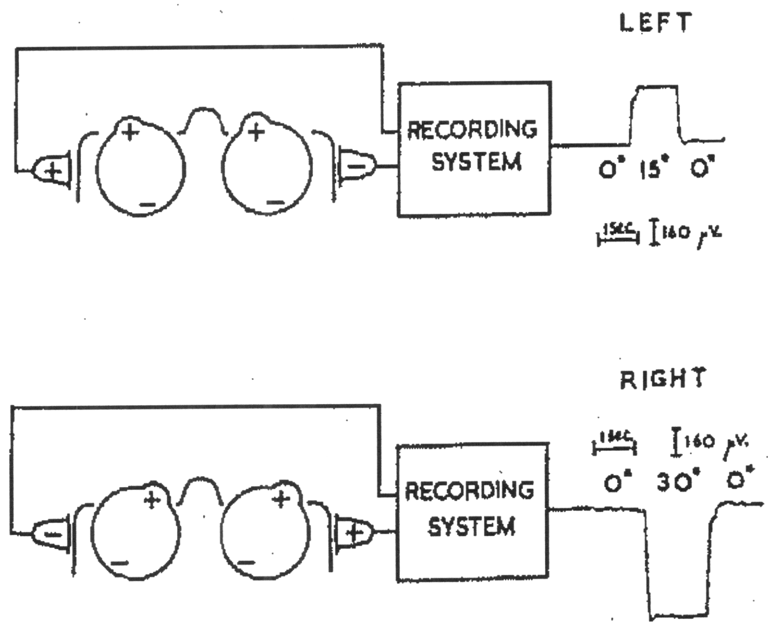


Figure 6.1. Technique of Electro-oculography. From B. Shackel, J. R. Davis and M. L. J Abercrombie, "Electrooculography in a Pilot Study of Cerebral Palsied Children," *IRE Transactions on Bio-Medical Electronics* 9 (Apr, 1962): 113.

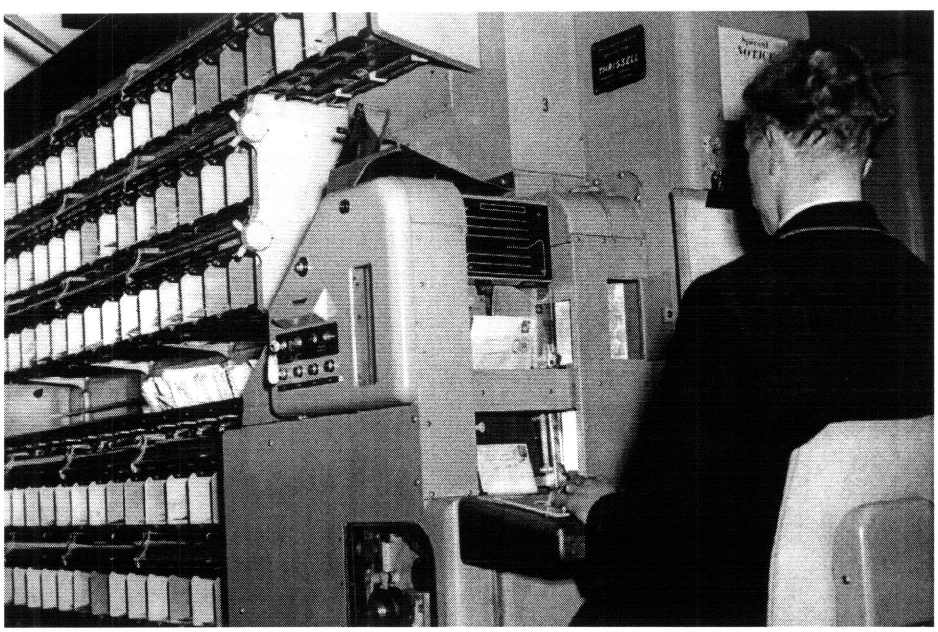


Figure 6.2. APU mechanized letter sorter. From L.A. Reynolds and E.M. Tansey, "The MRC Applied Psychology Unit," *Wellcome Witness to Twentieth Century Medicine* Vol. 16: 34. http://www.ucl.ac.uk/histmed/PDFS/Publications/Witness/wit16.pdf. Accessed January 23, 2008.

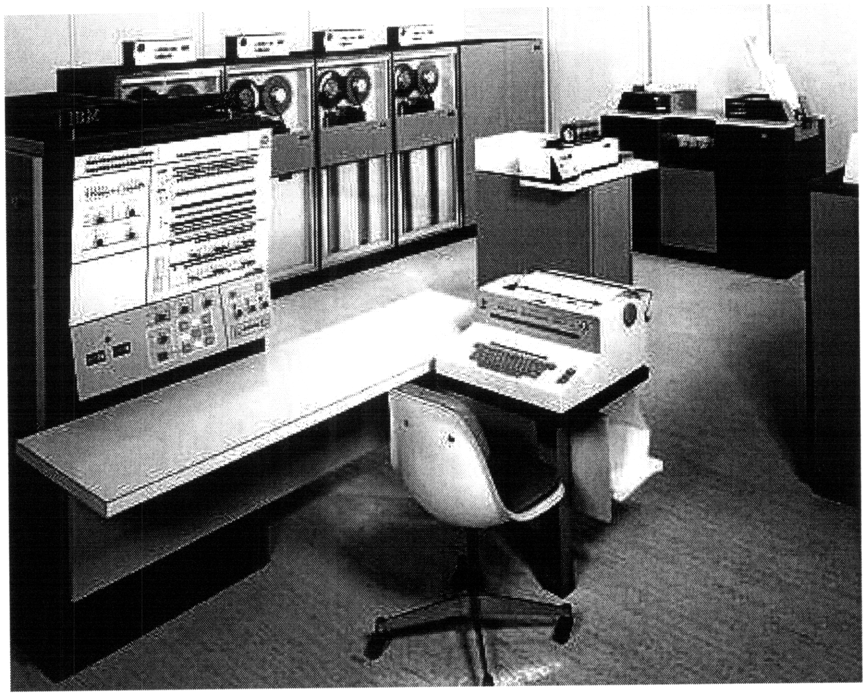


Figure 6.3. IBM System 360/ Model 40. From http://www-03.ibm.com/ibm/history/exhibits/mainframe/mainframe_PP2040.html. Accessed November 28, 2007.

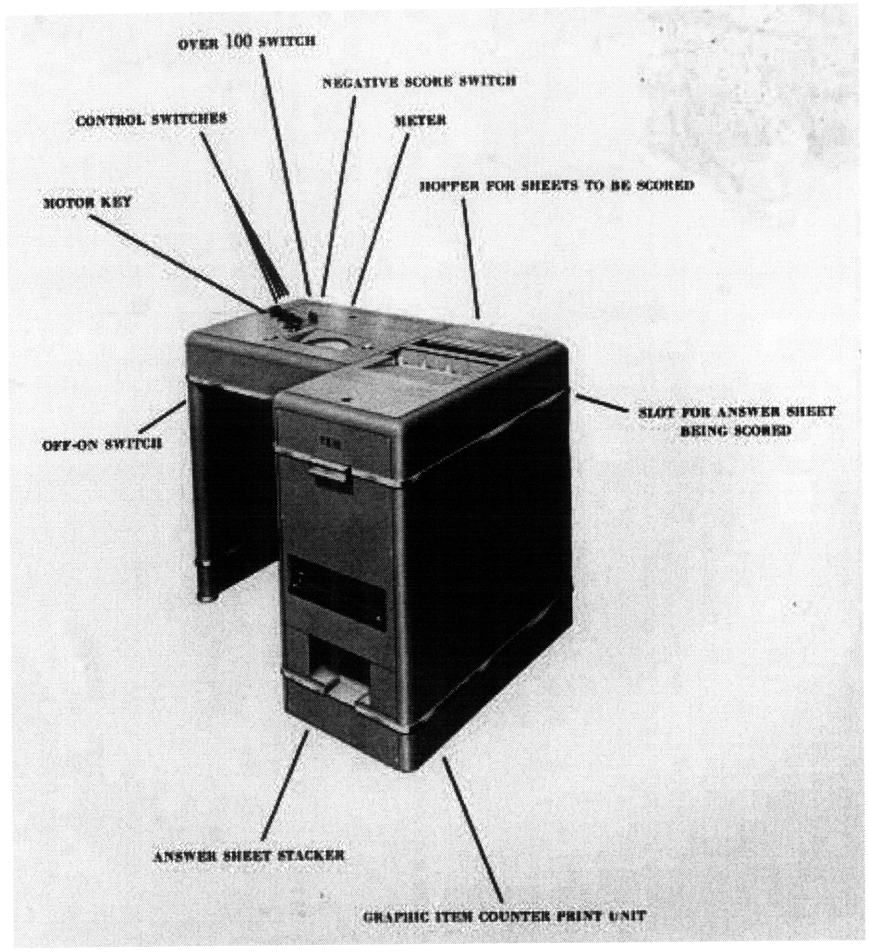


Figure 6.4. IBM 805 Test Scoring Machine. From http://www-03.ibm.com/ibm/history/exhibits/specialprod1/specialprod1_9.html. Accessed November 28, 2007.

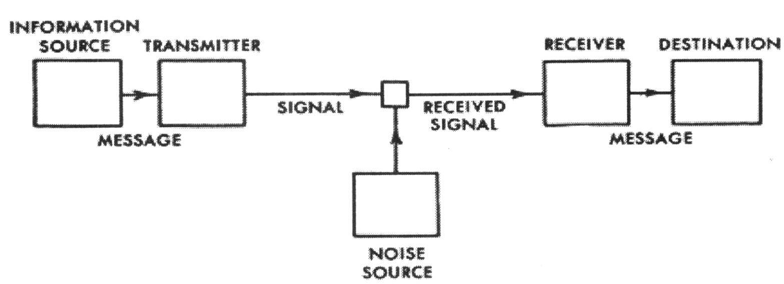
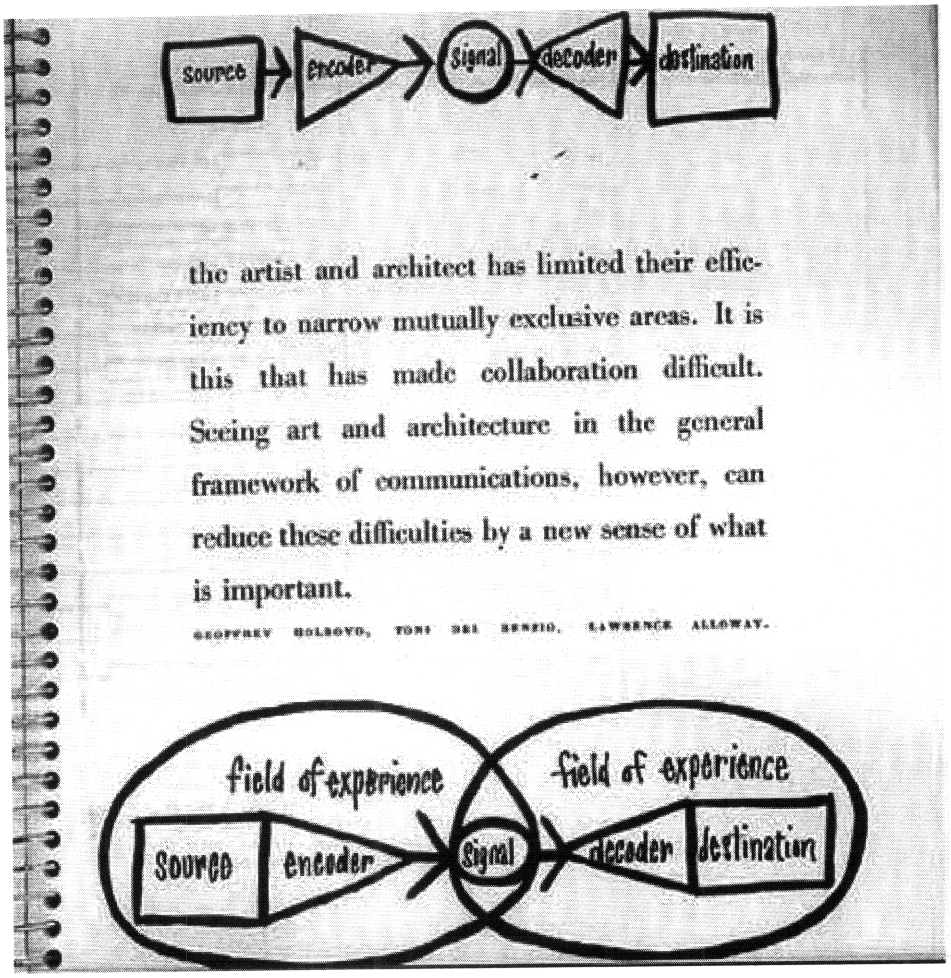


Figure 6.5. Claude Shannon's mathematical theory of communication. From Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949), 33.



the artist and architect has limited their efficiency to narrow mutually exclusive areas. It is this that has made collaboration difficult. Seeing art and architecture in the general framework of communications, however, can reduce these difficulties by a new sense of what is important.

GEOFFREY HOLROYD, TONI DEL RENZIO, LAWRENCE ALLOWAY.

Figure 6.6. The use of information theory at the *This Is Tomorrow* exhibition. From http://www.thisistomorrow2.com/images/cat_1956/cat_web/FrameSet.htm. Accessed November 13, 2007.

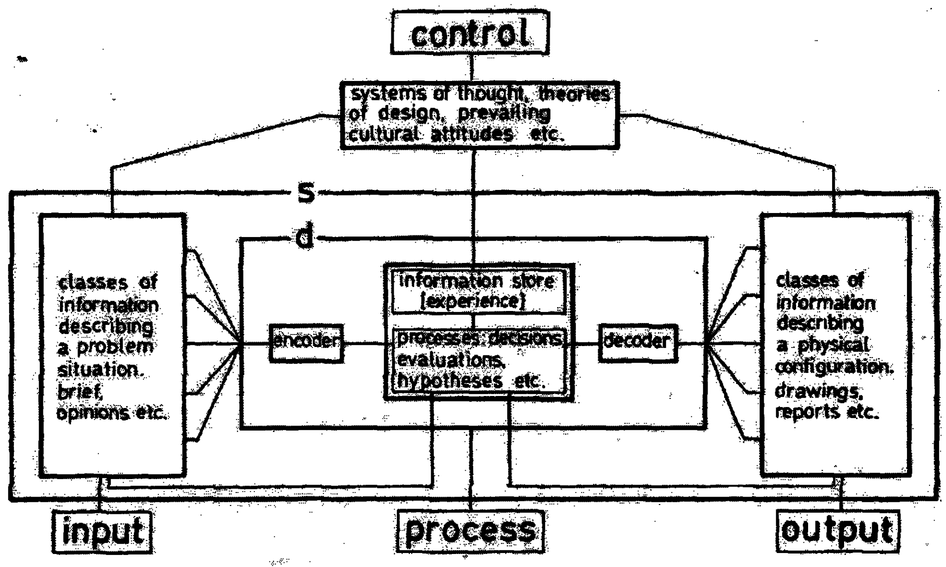


Figure 6.7. Gordon Best's design process. From Gordon Best, "Method and Intention in Architectural Design," Geoffrey Broadbent and Anthony Ward, eds., *Conference on Design Methods in Architecture* (London: Lund Humphries, 1969), 151.

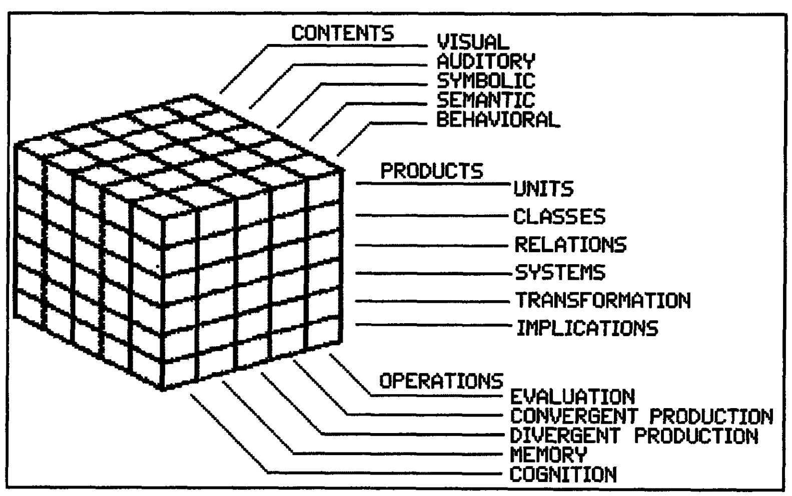


Figure 6.8. J.P. Guilford's structure of intellect model.

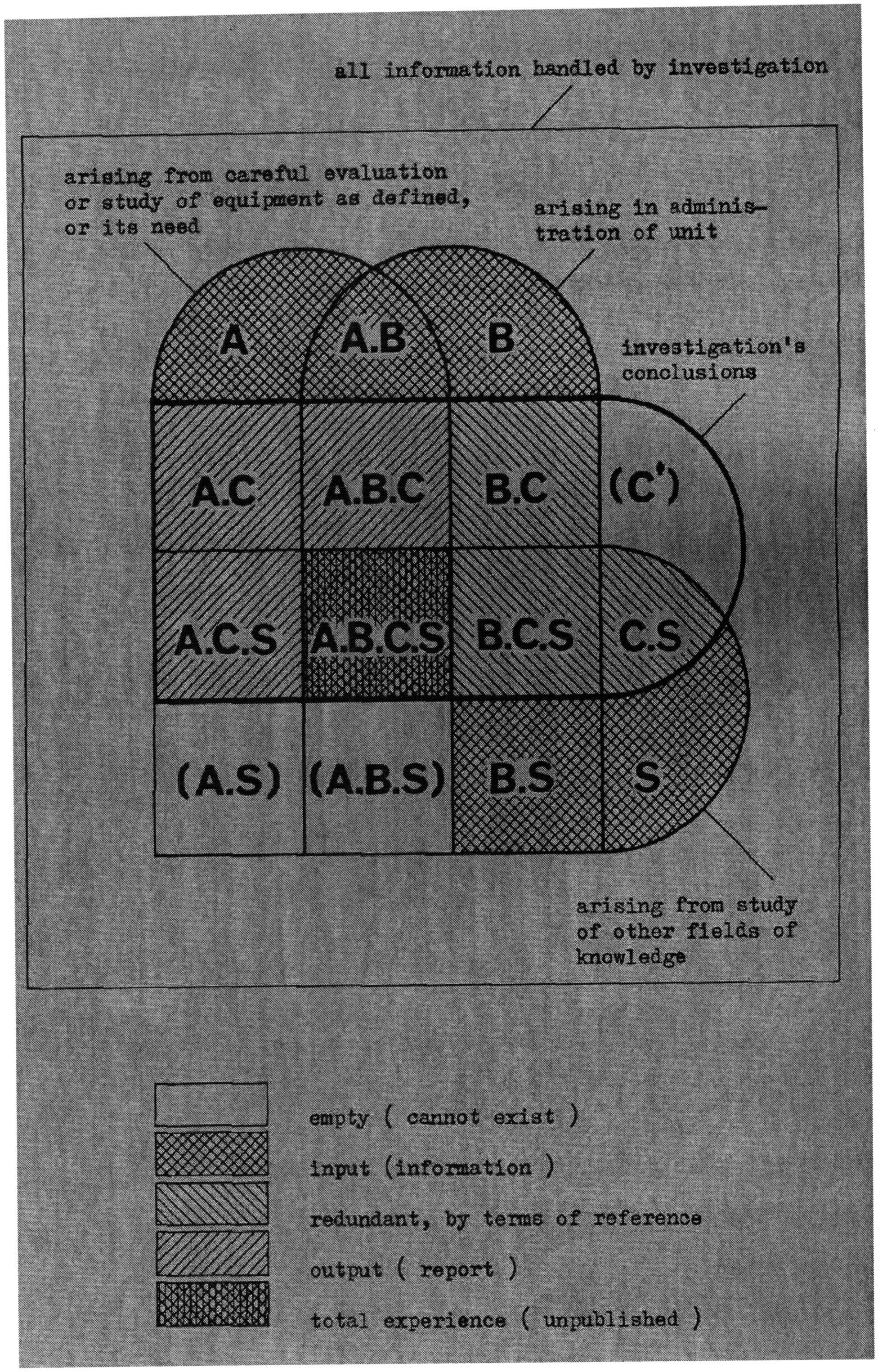


Figure 6.9. L. Bruce Archer's symbolic design method. From Misha Black and L. Bruce Archer, *Studies in the function and design of non-surgical hospital equipment. Supplement to preliminary report, November, 1962* (Nuffield Foundation; Royal College of Art, 1962), n.p.

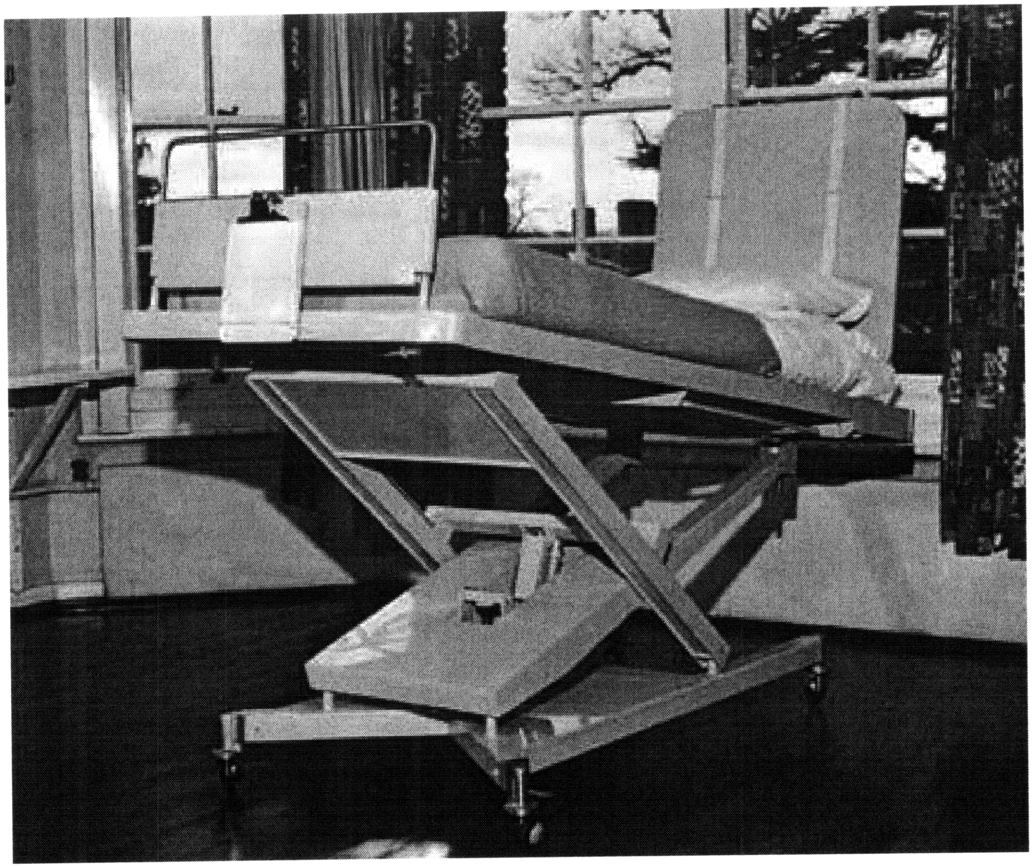


Figure 6.10. Hospital bed designed under L. Bruce Archer. From Ken Baynes, *Industrial Design and the Community* (London: Lund Humphries,1969), 56.

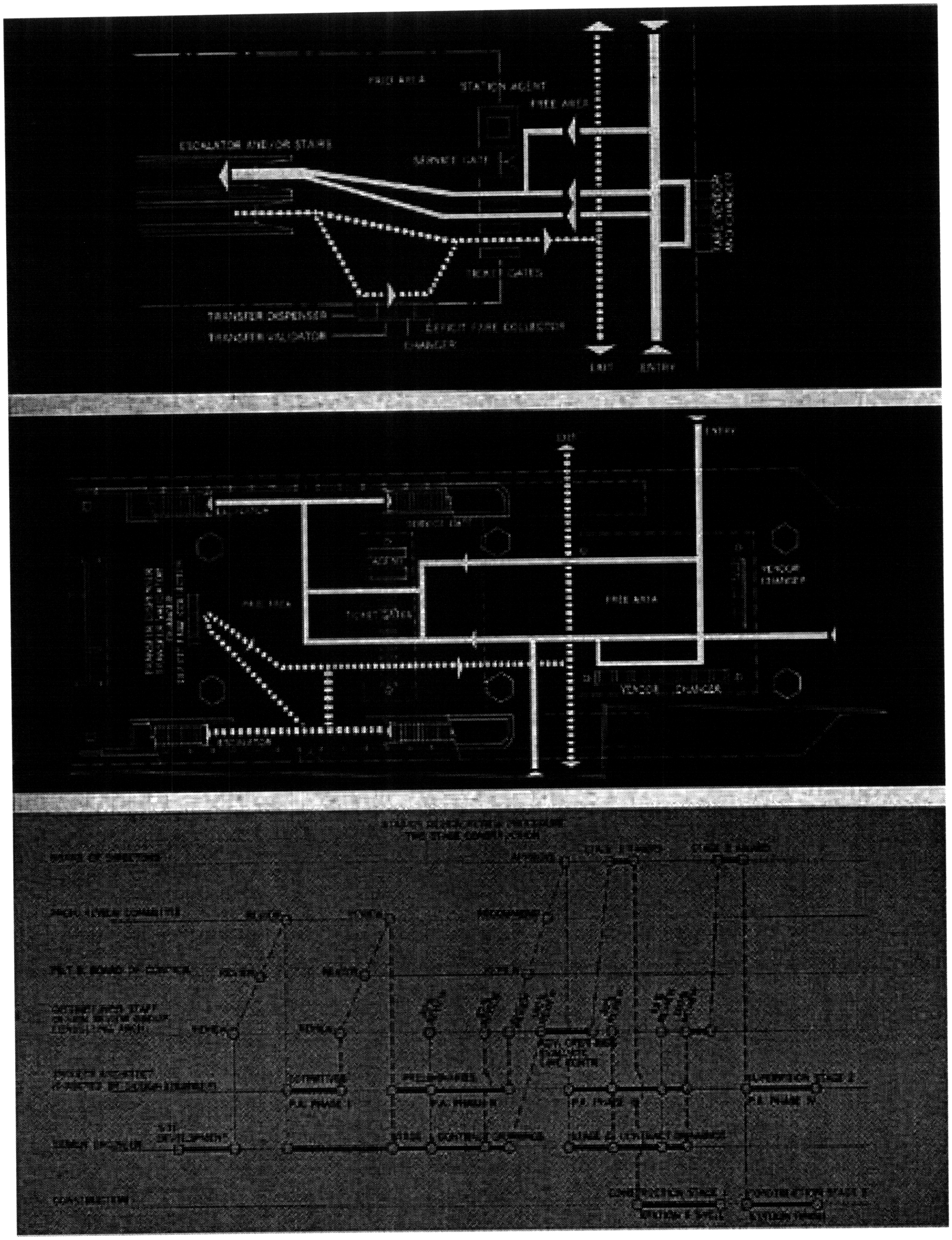


Figure 7.1. BART diagrams. The top two are for stations; the bottom represents the steps station design must pass through. From "BART," *Architectural Forum* 124, no.6 (1966): 52.

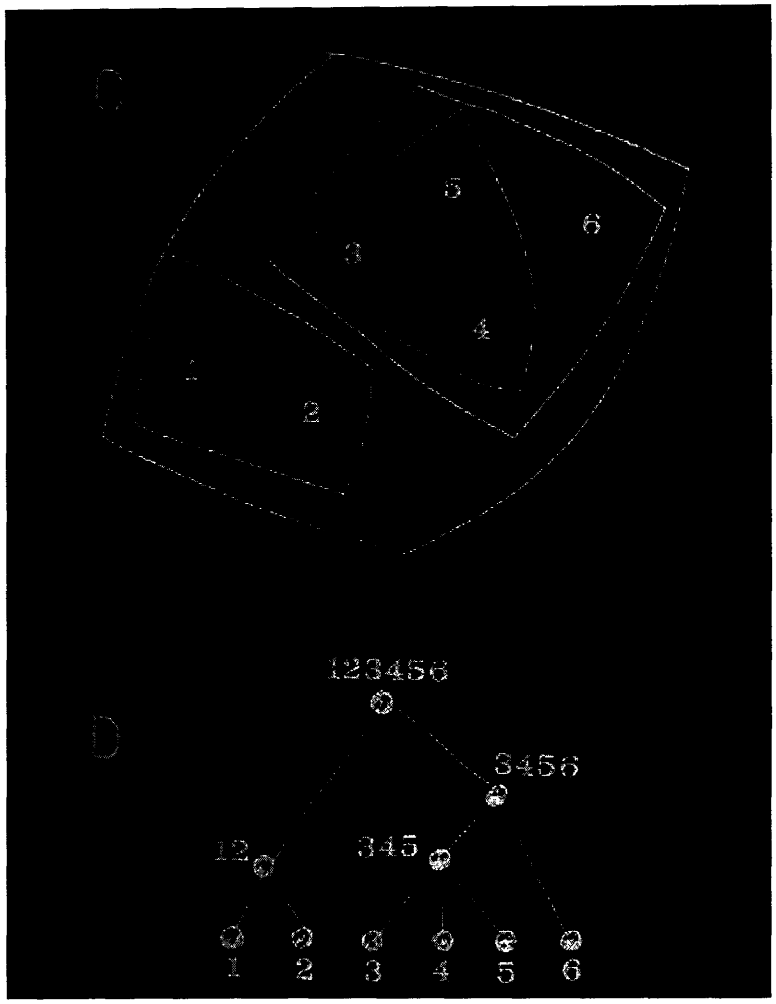


Figure 7.2. Tree representation. From Christopher Alexander, "A City is Not a Tree," *Architectural Forum* (April 1965): 59.

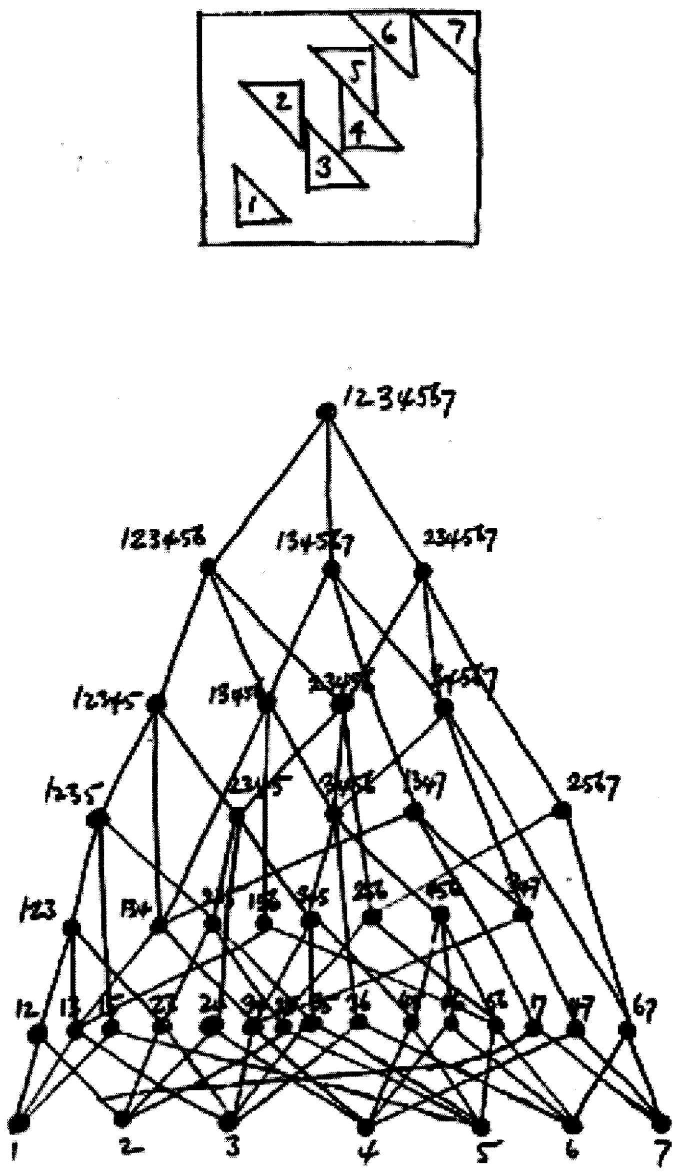


Figure 7.3. Lattice representation. From Christopher Alexander, "A City is Not a Tree," *Architectural Forum* (May 1965): 61.

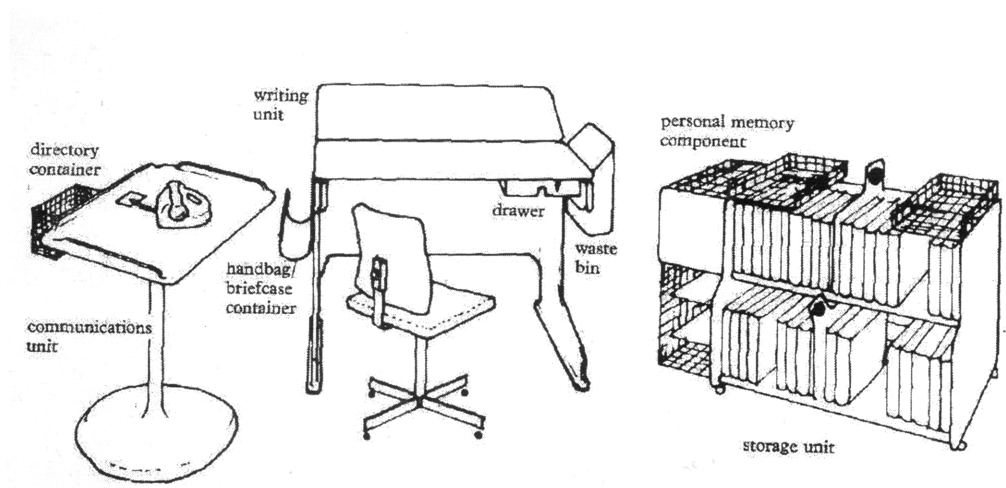


Figure 7.4. Experimental furniture for Prince Consort House. From Ian Moore, "Design and Development Programming," in Geoffrey Broadbent and Anthony Ward, eds., *Conference on Design Methods in Architecture*, 26.

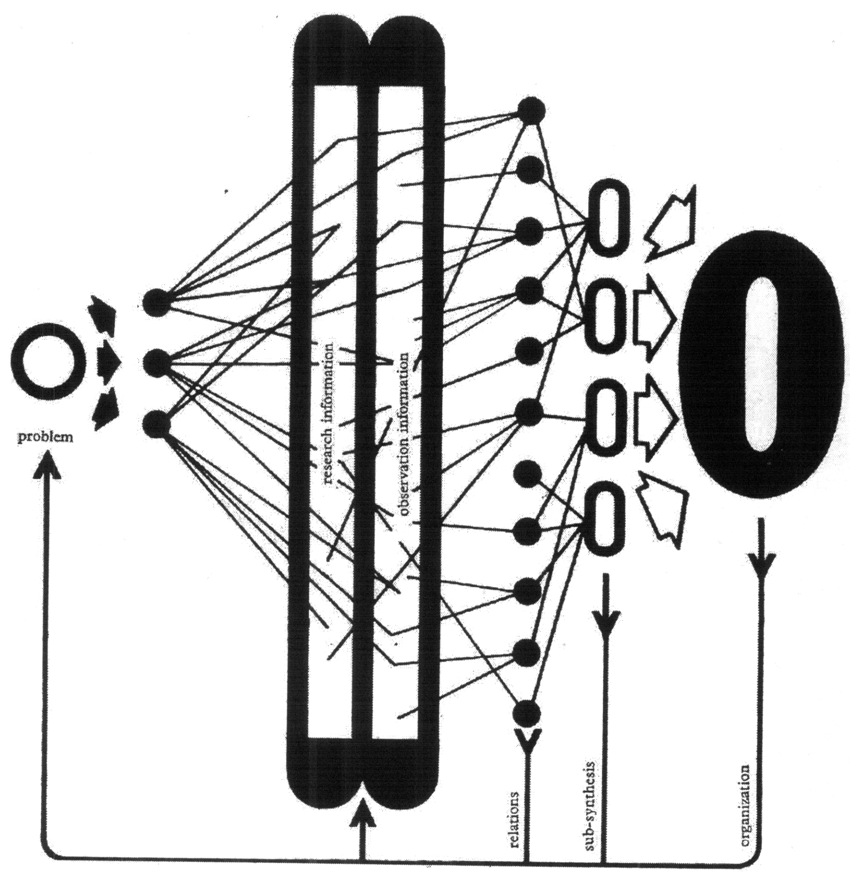


Figure 7.5. Neville Longbone's design method. From Neville Longbone, "The Physical Organization of Sheltered Workshops for the Blind," in Geoffrey Broadbent and Anthony Ward, eds., *Conference on Design Methods in Architecture*, 181.

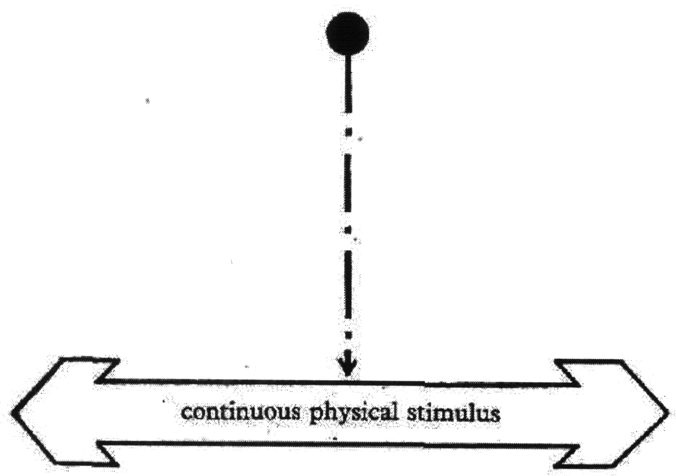


Fig. 6

Location

Tendencies:
1) Blind people try to walk reasonably quickly (2–3 m.p.h.).
2) They try and avoid disorientation.

Conflict:

A large open space will cause disorientation, unless the blind take a lot of time moving through or within it.

Relation:
No point in a workshop to be more than 15′ 0″ from some physical continuous stimulus.

Figure 7.6. Neville Longbone's use of relational method. From Neville Longbone, "The Physical Organization of Sheltered Workshops for the Blind," in Geoffrey Broadbent and Anthony Ward, eds., *Conference on Design Methods in Architecture*, 185.

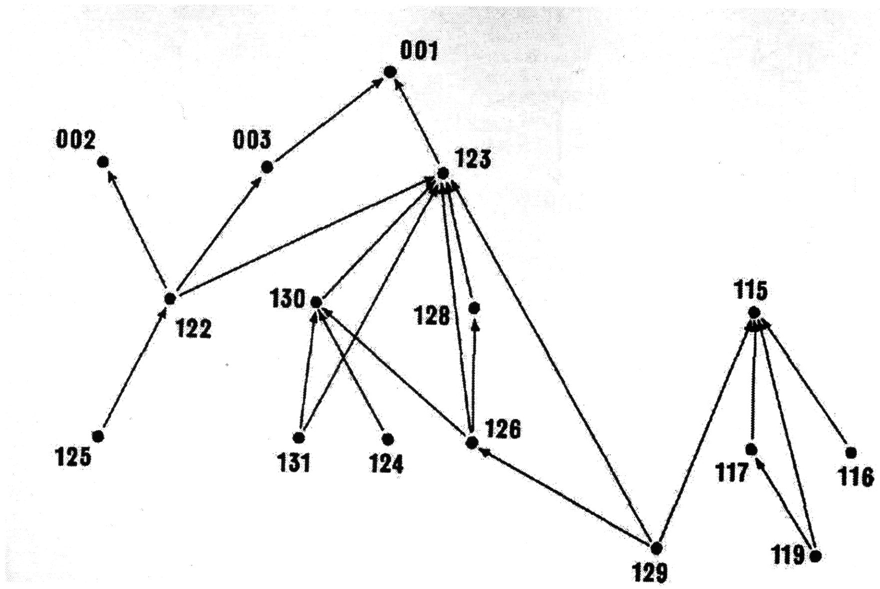


Figure 7.7. Poyner's depiction of relational method. Numbers represent problems and arrows their interactions. From Barry Poyner, "The Evolution of Environmental Structures," in Geoffrey Broadbent and Anthony Ward, eds., *Conference on Design Methods in Architecture*, 36.

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