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Abstract


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This dissertation explores the paradox of precision in postwar architecture, when dissonant aesthetic desires and concerns regarding environmental regulation forced a reconciliation of material techniques with theoretical accuracy. The modern ideal of exactitude was frequently at odds with the divergent processes of building research, engineering, manufacturing, and environmental management. Suspended within the strata of newly developed curtain walls was a suddenly critical technical and architectural problem: how to achieve the kind of modulated environment implied by the highly regulated lines and taut materiality of the glazed envelope. Unlike outwardly legible structural systems, typically celebrated as modernism’s heroic force, techniques of enclosure defined modern interior atmospheres. Precision was key to demarcating the interior environment, and architects relied upon the burgeoning building products industry for research on the most advanced techniques in glazing, component assembly, solar control, sealants, air-conditioning systems, and weathering protection. The dissertation is structured as four case studies of enclosure details from buildings accommodating diplomacy, industrial production, risk management, and global financial operations: the United Nations Secretariat building (1952), two factory buildings for the Cummins Engine Company (1966 and 1975), the headquarters of insurance broker Willis, Faber & Dumas (1975), and the headquarters of the Hong Kong and Shanghai Banking Corporation (1986). While the research centers on fragments of much larger
building projects, the analysis of particular enclosures unfolds to address the spatial reverberations of progressive societal shifts over the period, from internationalized conceptions of architecture and statecraft following the Second World War, through western corporate growth and global expansion during the 1960s and 1970s, to the emergence of a neoliberal economic regime inflecting the formation of corporate space during the 1970s and 1980s. The details scrutinized here delineate interiors that operate as microcosms mirroring global social and economic circumstances.
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Introduction: Building Fragments: Technology in Architecture and Architecture in Technology

Call it a biography of things, a filiation of objects, not as pictures in an exhibition, but as records of the process of their coming into existence...Instead of reading a history of objectivity from concepts, I embark on reading a history of objecticity from material traces.

Hans-Jörg Rheinberger

In 1972, amid projections of a global oil crisis and mounting concerns over prevailing levels of energy consumption, the president of the Royal Institute of British Architects, Alex Gordon, presented a proposal for “Long Life/Loose Fit/Low Energy” buildings: adaptable structures which would conserve material resources and minimize energy expenditure. On the surface, Gordon’s call for buildings defined by their outer limits—shell-like structures with flexible interiors to accommodate a range of functions—appeared to corroborate the contemporary argument for a systems-based approach to architecture, and his focus on the relationship of technology to energy consumption through the design of the building envelope prefigured the discourse on architecture and the environment that arose in subsequent decades. But while Gordon’s critique stressed the national and global implications of buildings’ energy consumption through the use of construction techniques which he considered extravagant, his disregard for the symbolic aspects of technology was polemical for architects and critics who adhered to a

disciplinary tradition of coalescing material techniques within compositional strategies. His focus on enclosure as the locus of energy problems only made the divide more conspicuous.

Some took Gordon’s prescription as a challenge to the image and function of technical precision; to them, long life, loose fit, and low energy described a retrogressive approach to architecture, out of step with the kind of technological developments seen in contemporary industrial or aerospace design. This perceived attack on precision was a rebuke to the practice of architecture in the vein of industrial design, with an emphasis on systems and the production of sleek, discretely contained forms. At the same time, in his push for low energy building techniques Gordon questioned the utility of an array of mechanized and computerized environmental management techniques that had been developed in preceding decades.

All of this took place within the context of an impending global energy crisis. The polarized response to Gordon’s transposition of scientists’ concerns regarding energy expenditure to the context of architectural practice indicated bewilderment over how to engage with techniques of construction and environmental management. To what extent should architects collaborate with industry to develop new materials and techniques in the interest of energy savings? Should building systems be legible on a building’s surface? How might clients, especially the industrial or corporate firms underwriting large projects, be served by particular building technologies? To what degree was the technical

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3 See Reyner Banham, "LL/LF/LE vs Foster," *A+U* 57 (Sept. 1975), 52-55. Banham denounced Gordon’s prescription as a “quasipolitical nostrum,” and instead advocated “Tight Fit” buildings like those of Foster Associates architects, which he claimed capitalized on the energy that was already being used, rather than reducing overall consumption.
precision which many architects prized an answer to aesthetic, environmental, or
economic concerns? At stake in this general confusion, and in the debates surrounding
Gordon’s proposition, was the status of the technological object in architecture.

If the quasi-autonomy of technical research and the development of building
materials and systems had been taken for granted up until that point, by the 1970s there
was a split between proponents of technology’s preeminence and symbolic force, and
those who questioned the viability of this stance. This dissertation explores the chasm
between these two perspectives, asking how we might begin to rethink the status of
technology in architecture through historical inquiry. It follows the development of
paradigmatic technical objects, each of which encapsulates a matrix of social, cultural,
technical, and environmental conditions particular to the era of its formation. Details and
fragments of building envelopes are treated as indices of the techno-cultural processes
surrounding their production, channels through which to read the material, spatial, and
social implications of aesthetic and technical desires made manifest.

The dissertation frames the pursuit of technical precision in the development of
thin-skinned glass buildings during the postwar years as an endeavor to reconcile
competing aesthetic, social, and economic concerns when the aspiration for modulated
interior environments interfaced with an impulse towards transparency. While the
research centers on fragments of much larger building projects, the analysis of particular
enclosures unfolds to address the spatial reverberations of progressive societal shifts over
the period, from the institutionalization of international diplomacy following the Second
World War, through western corporate growth and global expansion during the 1960s
and 1970s, to the emergence of a neoliberal economic regime inflecting the formation of
corporate space during the 1970s and 1980s. The details scrutinized here delineate interiors that operate as microcosms mirroring global social and economic circumstances.

**Historiographic Stakes**

This research has three primary objectives. The first is to elaborate upon conventional tectonic readings of technology in architecture by broadening the frame to include processes of technical research and production in the development of enclosure and environmental controls. Historians and critics of modern architecture typically privileged the outwardly visible aspects of architecture’s technics, and tectonic form was widely heralded as the heroic force of modernism. While Siegfried Giedion and Lewis Mumford were both invested in the wide-reaching social effects of technological development, their architectural analyses centered on tectonics. Giedion’s works on iron architecture of the 19th century and steel and glass architecture of the early 20th century both emphasized the outward expression of material construction systems. In his critique of mechanical functionalism and the language of bureaucracy, Mumford pitted what he called “the engineering side of building” against symbolic expression, arguing that one should not infect the other. Reyner Banham argued for a more expansive history of building technology in *The Architecture of the Well-Tempered Environment*, though he ultimately exhorted architects to integrate mechanical systems within a repository of design elements, conflating the visual representation of building techniques and systems with

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technical expertise. By eliding structural logics and instead focusing on techniques of containment, this research aims to complicate the relationship between technical performance and aesthetics. Enclosure, the boundary between exterior and interior, is at once the visible face of a building and a constituent of its internal environment.

The second objective of the dissertation is to expand the archive of architecture’s technologies to include construction drawings, detail studies, consultants’ meeting minutes, images and test reports for prototypes, engineering calculations, technical consultants’ research reports, communications with manufacturers, cost estimates, materials testing, weather and solar simulations, and heating and cooling load calculations, etc. etc. In the aggregate, these materials are a means to study the ways in which technical solutions depend upon a diverse group of collaborators using varied means of representation and communication. This expanded archive supports the dissertation’s argument that buildings should be read as sites for material, environmental, and social experimentation. Unlike scientific experiments confined solely to the clean, controlled space of a laboratory, the technological experiments of architecture are rooted in a messy material and social world. The technical research studied through this heterogeneous archive is not centered on abstract or theoretical conditions, but is inescapably linked to the particularities of context.

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The third objective of this dissertation is to counter the conventional monographic historical method by beginning with a technical object rather than a concept or process. When a technical solution is configured as neither the logical outcome of an architect’s desire, nor the inevitable consequence of engineering practices, both the narrative of a building and the presentation of technology’s aesthetic aspects are complicated. The object-centered model developed here could be compared to Bruno Latour’s translation model of technical innovation, which describes a continuous transmutation of ideas and concepts as they are communicated between parties in the development of a technological project, but while Latour disentangles the social relations embedded in the formation of technological projects, I want to frame technological invention in architecture as a cultural endeavor that produces social effects as technological objects become materialized in the world.7

Technology in Architecture

The coupling of technology and precision in the discourse on architecture was widely prevalent in the years following the Second World War, when architecture journals began to publish expositions on the ways in which the slew of scientific and technological innovations available in the wake of the war would affect the design and construction of buildings. In 1948 *Architecture Forum* published an issue on the theme of “Measure,” with the thesis that building performance had suddenly become more complicated than in

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previous decades, when architects dedicated themselves to the provision of shelter and “surface ‘esthetics.’” [Fig. 0.1] The postwar context elicited a new set of concerns:

We have learned more about the kinds of environment which people need in order to carry on their daily activities most effectively. Materials and devices have been developed to produce such environmental conditions. And, since such material and devices must be incorporated into buildings, the buildings themselves have come to be looked on as means of conditioning the working and living spaces which they enclose. There is great intricacy in designing and equipping today’s buildings, small as well as large. There must be, if each structure is to attain its potential usefulness. We have shown our strength; now we are showing our skill.”

The resolution of this intricacy would require accurate correlation of the techniques of building science within the practice of architecture. The journal cast the problem of enclosure and its “precise control of environment” as a key technical agent in the conditioning of interior space: “Rather than a barrier, the enclosure has become a filter between two environments: the natural climate of the out-of-doors and the man-made climate of the interior. The building shell must almost literally breathe, focus and adjust itself to the shiftings between these two.” [Fig. 0.2] The journal recommended various technical means for the suitable development of the building shell or envelope as environmental filter. These included laboratory studies into natural phenomena like light, heat, and sound transmission, air pressure, and vapor behavior; research and testing of

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8 “Measure,” Architectural Forum (Nov. 1948), undated prefatory page.  
9 Ibid., undated prefatory pages. “It is time to pause and take stock of our advance, to evaluate achievements to date…to measure the instrumentality of this architecture…The place of the architect in building is that of heavily contributing coordinator and chairman. He must understand the technologists’ approach, and they must comprehend his.”  
10 Ibid., 135.
building materials; and the development of new materials and techniques in response to this research.\textsuperscript{11}

Suspended within the strata of newly developed glass curtain walls was a suddenly critical technical and architectural problem: how to achieve the kind of modulated environment implied by the highly regulated lines and taut materiality of the glazed envelope. Unlike outwardly legible structural systems, modern interior atmospheres were defined by precise techniques of enclosure and largely invisible mechanical systems. To realize tightly demarcated interior environments architects relied upon the burgeoning building research industry for the most advanced techniques in glazing, sunlight control, sealant and adhesive materials, vapor barriers, air-conditioning, and laboratory studies on the effects of weather.

Signaling the aesthetic associations of expansive glazed curtain walls that figured prominently in postwar office towers and other large buildings, Siegfried Giedion characterized the slab formation of such towers as a flat, solid form, in which “a certain feeling of hovering, of suspension, emanates from the surfaces,” and Nikolaus Pevsner described the transparency afforded by modern glass building envelopes as the “‘etherealization’ of architecture.”\textsuperscript{12} The realization of these transparent suspended envelopes involved the resolution of dissonant research, design, engineering, and manufacturing strategies—a tangle of subjectivity and objectivity—within a single,

\textsuperscript{11} Ibid.
precise technique. What was the relationship between this particular pursuit of precision and the period’s general cacophony of technical and aesthetic aspirations? How were oppositions between inside and outside, universal and specific, custom and standard, expert and amateur, and nature and artifice intensified or allayed in the materialization of these smooth glazed skins?

During the period, a range of private and public entities including academic institutions, research and development arms of industrial manufacturers, and governmental technical agencies—components of what Eisenhower termed the military-industrial complex—bolstered a growing construction industry amid the general expansion of western economies. State-run agencies like the Building Research Station in Britain or the Building Research Institute in the United States worked to redirect the technical knowledge garnered for wartime endeavors towards domestic and commercial construction, and academic centers for technical research carried out studies on new material assemblies and their various environmental consequences. This institutionalization of building research was often underwritten by building products manufacturers, who collaborated with government-appointed scientists and academic researchers. Their findings were frequently published in pamphlets or presented at technical conferences.¹³

From the mid-1940s to the mid-1980s the landscape of research and production related to the technical aspects of building evolved in response to a shift from the internationalism of the interwar and immediate postwar years to a rapidly globalizing economy and world order. While this technical research was a largely American

¹³ See for example the Building Research Institute conferences of the 1950s and 1960s, or conferences and publications from building research centers at Princeton and MIT.
enterprise (although Britain, France, and Germany also took part), its products, in the form of newly developed building materials and systems, were exported to diffuse global contexts by architects, manufacturers, and contractors, whose operations grew increasingly geographically dispersed in the decades following the war. Meanwhile, the conspiring technical programs of corporations, academic institutions, government agencies, and the construction industry were typically classified under the domain of engineering and construction science, and generally excluded from histories of architecture. Even as historians continued to frame modern architecture in terms of its engagement with technology, the problem persisted of how to treat such technical research within the historical and critical discourse.

In relation to this aporia regarding the framing of technology within the discourse on modernism in architecture, this dissertation addresses several important themes throughout each of its case studies. The first concerns the notion of precision and its internal contradictions. How do the paradoxes inherent in the pursuit of material precision mirror other contradictions inherent the social and political context of a project’s development? I am working here to historicize the material and immaterial formulations of environmental enclosure in technical, spatial, and cultural terms. I argue that the impulse towards precision was not only instrumental in the technical delineation of enclosure but was also central to its ontological development. Over the period covered by this dissertation, as responses to environmental, social, and economic change grew increasingly chaotic, enclosure became more and more tightly described.

Next, the chapters each consider the historiographic import of scale. How does precision operate across scales? How might we begin to read the world in a detail, or to
make discoveries about society through a study of a technical object at close range? How might we begin to trace connections as we zoom out progressively from techniques of enclosure, to interior environment, to building form or typology, to site, to clients and manufacturers, and to their national and worldwide business operations? What does a focus on the threshold between interior and exterior realms and the relationship between micro and macro scales reveal for the history of architecture?

Given this focus on architecture’s object-hood, the following theme concerns problems of technical assembly in the joints and material compositions being analyzed. Does the kind of systematized assembly of components seen in these case studies cast architecture as tantamount to industrial design? Questions of representation and symbolism are contained within this examination of enclosure’s assembly. Technics here has much more to do with the packaging of buildings using component systems and the configuration of artificial interior environments than it does with any structural logic.¹⁴ My research considers the aesthetic dimensions of architecture’s technologies in relation to a spectrum of production that took place over the period covered by the dissertation. The transition from a modern and industrial to what came to be termed a postmodern and postindustrial society was reflected in these figurations of enclosure’s technical composition.

The constitution of environment also undergoes a shift from the earliest case study to the last, and the dissertation traces the ways in which environment is formulated by collaborations between architects and technical consultants. What are the technical

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and discursive means by which environment is constructed in each of these projects? In what ways was this constructed and managed environment treated as a feature with both quantitative and symbolic facets, much like image or performance? How does the management of environment serve intersecting objectives such as social engagement, worker productivity, and financial gain? Felicity Scott’s framing of environmental management as a means by which architecture participated within an expansive web of technological and political forces shaping the postwar global order has influenced my thinking about the evolving configuration of environment across the arc of this dissertation.

The next theme regards the relationship between techniques of enclosure and the establishment of productive interiors. How does the social space of labor get re-imagined across the range of these cases? How did the formulation of standards for workspace layout and design—such as theories of labor management, Bürolandschaft, or the design manuals of figures like Francis Duffy—become absorbed within the enclosed interior configurations studied here, spaces developed expressly to maximize productivity in environments for economic and informational exchange, such as offices, factories, and banks? What are the political implications of containment when enclosure is considered

17 Whereas Daniel Barber’s study of environmentalism and modernism in the development of solar houses addressed the production of domestic architecture using techniques of energy conservation, this research examines spaces of labor and
in terms of its role in regulating a workforce, or the carrying out of particular economic agendas?\textsuperscript{18}

Zooming out further, the final major theme of the dissertation is the changing relationship between corporations and society during the period spanning from the mid-1940s through the mid-1980s, when the United States and Europe witnessed the rise of neoliberal economic policy which resulted in increasing commercial competition, privatized social programs, and a splintered labor force. While corporations and the state were becoming more pervasively interlinked through the development of public-private regulatory frameworks—a hallmark of the shift from \textit{government} to \textit{governance}—individuals were increasingly responsible for their own well-being, and in place of the capacity to collectively organize they were offered individual freedom and flexible choice.\textsuperscript{19}

Each of the case studies in this dissertation addresses to varying degrees the convoluted manifestation of corporate strategies and ideals within the material, spatial, and environmental configurations of buildings. Reinhold Martin’s work on corporate space has informed this dissertation by laying out the ways in which techniques of architecture became integrated within a corporate media apparatus from the mid-20\textsuperscript{th} productivity, where environmental management became an increasingly valuable tool to organize working processes and to maximize efficiency. See Daniel A. Barber, \textit{A House in the Sun: Modern Architecture and Solar Energy in the Cold War} (New York: Oxford University Press, 2016).

\textsuperscript{18} Michelle Murphy’s study of the biopolitical controversy surrounding containment in late modern office buildings pushes back against strictly abstract and functionalist interpretations of offices as the spatialization of capitalist profit models. Michelle Murphy, \textit{Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers} (Durham, N.C.: Duke University Press, 2006).

\textsuperscript{19} David Harvey, \textit{A Brief History of Neoliberalism} (New York: Oxford University Press, 2005), 77.
century on, producing not only images to circulate but also shells to accommodate the inner workings of the late capitalist body. Through this analysis of sealed, contained, and managed environments which were constructed precisely to sustain the boundless growth of corporate capitalism, I hope to demonstrate the ways in which this shift in the balance of power between individual laborers and employers, but also between individuals and a civil society increasingly under the sway of corporate sovereignty, was inextricably linked to the architectural techniques of enclosure.

Building Fragments
The dissertation is structured as a series of case studies of building fragments pertinent to the explication of environmental enclosure. The cases are organized in chronological sequence, but are drawn from geographically diverse sites: postwar Manhattan, the landscape of northern England in a period of economic recovery, the industrial plains of Indiana, the English market town of Ipswich, and Hong Kong. The typologies studied—an office tower for a diplomatic institution, two factories, a deep-plan office building, and a bank—also challenge typical interpretations of postwar networks of corporate power by suggesting that architecture’s role in the substantiation of such networks was not limited to the context of urban business districts but rather encompassed spaces for industrial production, as well as the dispersion of corporate workspace to extra-urban sites from the 1970s on. Rather than representing banal commonalities of the era’s architecture, these

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cases were selected to illustrate critical instances of intermingling aesthetic, technical, environmental and social concerns.

Chapter 1, “A World Contained: The United Nations Secretariat, Technical Research, and the Curtain Wall, 1946-1953,” examines the development of the Secretariat’s expansive glass skins, at the time the largest transparent suspended walls ever produced. Surfaced on its two broad sides with thin, flat glass, the building’s overt transparency was the putative figuration of democracy. Pushed outside the structure, these suspended glass screens mirrored their surroundings and suppressed the building’s internal framework. To intensify this effect, the Secretariat’s architects concerned themselves with the expression of a smooth skin, the detailing of which involved a translation of aesthetic desires and environmental requirements into a technical solution. I analyze the technical challenges involved in rendering the smooth, transparent glass curtain wall an effective environmental enclosure, and the various collaborations necessary to its production.

Inside the building, individualized environmental controls were purportedly integrated to foster greater cooperation between members of the UN’s international workforce. The technical and environmental paradigm of the Secretariat’s expansive glass skins and controlled internal atmosphere was intended to symbolize international diplomacy. While the building was situated in Manhattan, the project was as much an overt representation of internationalism as it was American. There was a contradiction between the UN’s pacifist conception of the international sphere and its programs, which upheld North American preeminence by consolidating principles of scientific internationalism.
and technocracy to promote international development through diplomacy and technical
government.  

Through an investigation of the intricate negotiations involved in the resolution of
technical façade details I aim to delineate the material constitution of an internationalized
architecture designed to contain the new world order, both symbolically and
environmentally. The chapter concerns itself with dual tensions between the building’s
representation and its technical performance, and between the institution’s symbolic
internationalism and its actual operations, which more resolutely served the interests of
western capitalism. The precision inherent to building’s bureaucratic technical language,
and to the architects’ endeavor to circumscribe environment as a manipulable entity, was
implemented as a means to overcome disorder and uncertainty in the realms of material
production, environmental configuration, and worldwide political relations.  

Chapter 2, “An Environment for Industry: The Cummins Engine Company and
the Commercial-Philanthropic Sphere, 1963-1975,” investigates techniques of enclosure
in two glass factory buildings designed for Cummins by Kevin Roche John Dinkeloo
Associates (KRJDA): one in Darlington, England, completed in 1966, and one in

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21 Mark Mazower details the tension between Americanism and internationalism in the
development programs of the United Nations. Its Security Council—dominated by the
five permanent members of Great Britain, the United States, France, China, and Russia—
mirrored and maintained the worldwide balance of power that had been established
during World War II by imposing its resolutions on both members and non-members of

22 Felicity Scott has demonstrated the means by which by bodies such as the United
Nations undertook a complex reticulation of architecture with environmental
management in programs to address urban, national, and international insecurity in the
decades following the completion of the Secretariat. Felicity Scott, Outlaw Territories:
Environments of Insecurity/Architectures of Counterinsurgency (New York: Zone Books,
2016).
Walesboro, Indiana, completed in 1975. In comparing these projects I analyze how an American industrial corporation that presented itself as the most socially progressive of its time negotiated a precarious balance between efforts towards global expansion and domestic production operations through a range of tactics including business plans, facilities construction, social programs, and involvement in governmental policy formation.

This chapter scrutinizes the symbolic implications of transparency for the factory typology, as well as the technical constraints particular to the material configurations studied here. These buildings relied upon precise detailing to maximize transparency and to dematerialize the bounds of the factory, thus establishing enclosure as both an opening up to the natural landscape and the delineation of a microcosm meant to model environmental and social programs symbolic of a progressive corporate ethos. In these factories, materials and assemblies more typically developed for corporate office buildings were repurposed for industrial manufacturing. As both symbol and vessel of corporate social responsibility, these precisely composed glass-skinned enclosures functioned as components of the corporation’s efforts to balance its global presence with increasingly volatile domestic social and economic conditions during a period of widespread industrial decline.

This case study involves a number of contradictions: between a corporation’s outwardly projected progressive image and its obscure strategies for financial gain; between the development of factory buildings to symbolize an industrial corporation’s technical expertise and social agenda, and a general decline in the industrial sector of the American economy; and between the use of architecture to represent environmental
sensitivity—also known as ‘greenwashing’—, and the company’s own financial entanglements with the political opposition to environmental protection.

If the philanthropic endeavors of Cummins Engine Company marked the emergence of an idea of social responsibility whereby corporations could ostensibly serve themselves and society in equal measure, the treatment of the factory interior as a microcosm of the relationship between labor and business, and between business and environment, highlights the paradoxes laid out above. Indeed, the company’s financial dealings paid for the opportunity to present a progressive stance through the construction of buildings like these factories. Cummins’s socially and environmentally progressive programs—such as affirmative action for racial diversity or improvements to the factory environment—were precisely underwritten by, and a boon to, the corporation’s overall profitability through more obscure and globally diffuse business operations.

Chapter 3, “Nothing but Glass, Glue, and Conditioned Air: Precision and Emptiness at the Willis Faber & Dumas Headquarters, 1971-1975,” details the design of a minimized glass skin to envelop a deep and fully air-conditioned office interior that served as a paradigm of productive space in which spatial flexibility, environmental management, and the insertion of agreeable amenities and conveniences were intended to gratify the workforce. This building, by British architects for a British client in a British town, was nevertheless a component in the emerging global risk-based economy, as it housed the operations of insurance broker Willis Faber Dumas, who were known for guaranteeing a range of technical development projects worldwide.

The chapter explores the technical criteria for the construction of nothing in a building that assumed aesthetic and programmatic impulses towards emptiness. Enclosed
with the thinnest of glass membranes—a patchwork of panels held together with silicone “glue”—this building was a self-contained environment intended to enhance social relations in the name of productivity. Techniques of spatial management and principles of office planning were employed together with environmental conditioning in this model of tightly enclosed conditioned interior. Here precision was used to effectively dematerialize the building so that its technologies were not immediately legible; this drive towards nothingness was a-tectonic but still semantic in that it represented a desire to naturalize the work environment within a bubble of productivity. The razor-thin membrane separating the interior and exterior realms reinforced a sequestering of productive space inside from the surrounding city. At turns mirrored and obscure, then a transparent lens into the workings of the company, this skin manifested a tension between the building’s function as a symbolic object and its distillation of efforts to form a contained and regulated space for work and leisure.

This was a new model for the productive environment created by an emptied out interior, a flexible and open space to be filled with a changing array of amenities to enhance the lifestyle and comfort of the worker. There was an intentional paradox between the cool world of financial services accommodated in the productive space of the Willis, Faber & Dumas building, and its warmed-up, pleasurable interior environment, intended to produce contentedness within the bounds of the workspace and to displace external social networks, especially within the context of a headquarters moved outside the nation’s financial center. The building developed an internalized model of the social world of the corporation; cut off from the city at large, the social
sphere is only relevant in this building insofar as it increases internal communications and employee satisfaction in the service of the company.

The last chapter, “The Value of Enclosure: Environmental Performance and Commercial Viability at HSBC, 1979-1986,” concerns the construction of a headquarters for the Hong Kong and Shanghai Banking Corporation (HSBC), a building which at the time was reported to be the most expensive ever produced in the modern world in terms of both total budget and cost per square foot, an attribute employed variously as a critique and a selling point. A multinational financial institution, HSBC was also integral to the governmental structure of the British-ruled territory of Hong Kong, a holdover from colonial rule that was on the precipice of being handed back to China. Signaling a shift in geopolitical order from Western- to Eastern-centered economic activity, the new headquarters building was to cement HSBC’s foothold in Hong Kong, even as the bank pursued outward international expansion.

The chapter explicates the development of the typical glass curtain wall used throughout the HSBC tower, a technical object that was classified as an enhancement to business operations for its capacity to modulate an interior environment devised to accommodate newly digitized and accelerated global financial transactions in response to rapid market fluctuations. This computerized workspace prompted research that was used to codify optical, lighting, and atmospheric conditions as screens interacted with glass facades. At HSBC, enhanced climate controls stood for prospective productivity, conditioning the interior to sustain an increasingly digitized system of exchange.

The architects’ narrative of the project privileged precision and efficiency in material and energy techniques, drawn from aerospace and high tech industries, and
accentuated their facility with intricate global labor and production patterns required to realize the building. However, rather than following a path from advanced technique to optimal efficiency, the design and construction processes were fraught with disputes over calculations, standards, and bottom lines, driven as much as by qualitative interests as by quantitative ones on the part of the client, architects, engineers, and consultants; emphasis upon technical proficiency belied their aesthetic motivations.

The client justified the capital costs of the headquarters’ “criteria of performance” in terms of commercial viability: the building’s flexibility created value, allowing HSBC to competitively respond to an unknown future. The headquarters presented an environmental paradigm in which energy efficiency correlated to commercial acuity. As the symbolic prowess of the institution was invested within the tower’s overtly technical language, the enclosure suspended within its exposed armature accommodated invisible yet volatile financial and environmental systems requiring complex management techniques. There was a contradiction between the political and economic uncertainty of Hong Kong and this tightly managed interior environment. Flexibility was a means to control the financial risks of the future, an investment in future profitability.

While the United Nations Secretariat building construed environmental control in terms of diplomacy, and the Cummins Engine Company factories configured environment to foster social diversity and integration, and the Willis Faber & Dumas headquarters formulated environment as a self-contained social sphere, the HSBC building offered no pretense of social engagement at all. Hovering over a public plaza, from which the citizens of Hong Kong were invited to peer up through a glass “underbelly,” the building sharply segregated social space from the realm of financial
operations. Internally its environment maximized profit, and externally, the headquarters building itself was to present an image for global circulation, transmitting confidence in Hong Kong’s then uncertain political and economic future.

Architecture in Technology

While recent disciplinary and material histories by Andrew Saint and Adrian Forty have filled gaps in the knowledge of architecture’s technical aspects, missing in such accounts was a study of architecture’s epistemic objects, those technical and material particulars whose very realization substantiates the social conditions surrounding their development and creates a paradigm for subsequent formations.23 How were certain tropes of architecture’s modernism—transparency, the disintegration of the inside-outside divide, the industrialization of building, and accuracy in composition—linked to technological forces in both overt and covert ways? How would a history of architecture that begins with an object or fragment provide a different reading of technology than a monographic history, or one that begins with an idea?

Rather than simply providing a more intricate technical history of modern architecture, this project is also intended to broaden the scope of studies in science and technology. How might the architectural fragments investigated here be cast within broader accounts of technological change? Could an epistemic object of architecture be the basis of a social history of technology? While Thomas P. Hughes has indicated

architecture’s role in the formation of an “ecotechnological environment,” in which natural and human-built environments intermix, the histories of this entanglement of architecture, engineering, and environmental science remain largely unwritten.24

An investigation of precision necessarily involves the consideration of error as the inverse condition it defends against. The presumption of scientific objectivity and truth to the natural or material world is itself fraught with a multiplicity of perspectives and interpretations.25 Work by philosophers and historians of science such as Bruno Latour or Evelyn Fox Keller to parse the means of scientific analysis—ways of representing and evaluating technical developments—has done much to demonstrate gaps between what is presented as technical fact and the social construction of that scientific knowledge.26 Latour’s dissection of failure, or a series of compounded errors, as a means of discrediting a notion of technological progress perpetuated by the exclusive historicization of technological successes, offered a corrective model to linear portrayals of technological developments in architecture. Fox Keller’s investigation of the role of intuition or “feeling” in scientific practice through an upending of experimental hierarchy similarly broke down the primacy or autonomy of rational, objective science.27

27 Fox Keller charts the scientific practice and career of cytogeneticist Barbara McClintock, and her ability to make intuitive jumps from the level of a chromosome to that of a whole organism: “It was her conviction that the closer her focus, the greater her attention to individual detail, to the unique characteristics of a single plant, of a single kernel, of a single chromosome, the more she could learn about the general principles by which the maize plant as a whole was organized, the better her ‘feeling for the organism.’” Ibid., 101.
Francesca Hughes exposed the political and aesthetic ramifications of error in 20th century architecture culture but did so using objects from architecture’s periphery such as the visual arts, aeronautical engineering, life sciences and cybernetics, etc. Like Hughes, I want to contest the idea of technical supremacy, but my project attempts to dissect the importance of ideas about precision, success, and failure in the resolution of architecture’s most impassive technical objects at a minute scale. The technological processes involved in their development were rife with disputes, errors, and misalignments. In querying the aesthetics of precision this dissertation aims to destabilize technology as a monolithic, autonomous, immovable category.

If the gamut of architecture’s techniques may be understood to possess both performative and symbolic dimensions, how might their analysis force a positioning of techno-aesthetic questions alongside the socio-technical ones normally posed? Moreover, how might a consideration of semantics complicate the framing of these technical objects within the contexts of modern and postmodern culture? While sociologists of science like Michel Callon and John Law have studied the ways in which technological development is dependent upon an array of heterogeneous material, social, and strategic factors, this project insists upon culture’s significance within a diverse network of influences on technical development. In that respect this project has affinities with Simon Schaffer’s work on the cultural conditioning of accuracy and exactitude in scientific practices of Victorian England, or with Emily Thompson’s presentation of the modern subject as

shaped by a technically constituted aural environment.\textsuperscript{30} My research is distinct from such works, however, in that it addresses both the technical and the semantic in its analysis of containment and environmental management, thereby presenting a history of technology that takes up both modern and postmodern cultural frameworks.

While this dissertation offers no prescription for the technical formation of architecture or enclosed environments, its portrayal of the recent history of such endeavors does reflect upon the enclosures we currently occupy. As the conditioning of interiors becomes simultaneously more technically codified and less immediately visible, how are we to make sense of the interiority of environmental enclosure described in this dissertation as something quite distinct from the rubrics of interior space typical to architecture history? Who are its subjects? Who are its agents? What kind of exteriority does it allow? When global architecture development depends upon techniques of enclosure to populate desert cities, to demarcate the towers of urban business districts, or to provide a lucrative face for high-tech industries, then a history of the heterogeneous formulation of enclosed environments necessarily demonstrates architecture’s participation in the creation of a spatio-atmospheric model underlying contemporary systems of information and financial exchange—the office buildings and production facilities we build today. The negotiation of precision is crucial to this spatial model, in which architecture is both networked and materially specific, and environment is something both vast and confined, locally constituted and globally projected.

Chapter 1:

In 1939, Siegfried Giedion characterized the “skyscraper slab form” as a tall, flat, solid building with two broad and two narrow sides which developed as the natural outcome of the technical and economic needs to provide adequate lighting for every square foot of usable space. The principal example of the form was New York City’s R.C.A. building at Rockefeller Center, completed in the same year, of which Giedion wrote: “It can be perceived that when a great height is combined with the thinness of the structure, a certain feeling of hovering, of suspension, emanates from the surfaces…” Completed in 1952 on a site in midtown Manhattan, the Secretariat building within the United Nations (UN) headquarters presented a new iteration of the slab formation, but unlike the more massive versions that preceded it, the Secretariat tower was surfaced on two sides with thin, flat glass. Amplifying the logic of the RCA building and enhancing the superficial sense of weightlessness, the Secretariat’s envelope was pushed beyond the extremes of its structure, a suspended screen mirroring its surroundings. In suppressing the building’s internal framework, its architects concerned themselves with the expression of a smooth skin, the detailing of which involved a translation of aesthetic desires and environmental requirements into a technical solution [Fig. 1.1].

31 Siegfried Giedion. Space, Time, and Architecture: The Growth of a New Tradition (Cambridge, MA: Harvard University Press, 1941), 848-849. This book consolidated the lectures and seminars Giedion gave while he was the Charles Eliot Norton Professor at Harvard University from 1938 to 1939. Rockefeller Center was designed by Associated Architects, a committee of architects including Raymond Hood, Godley & Fouilhoux; Reinhard & Hofmeister; Corbett, Harrison, & McMurray; and Edward Durell Stone. See Carol Krinsky, Rockefeller Center (New York: Oxford University Press, 1978).
Central to this process was an attempt to resolve the dissonance of research, design, and engineering strategies—a tangle of subjectivity and objectivity—within a single, precise technique. Suspended within the strata of the Secretariat’s curtain walls was a suddenly critical technical and architectural problem: how to achieve the kind of modulated environment implied by the highly regulated lines and taut materiality of the window wall. This chapter examines how a discourse on precision emerged from interactions between various collaborators involved in the realization of the Secretariat’s glazed skins. What was the relationship between this particular pursuit of precision and the period’s general cacophony of technical and aesthetic aspirations? How were oppositions between inside and outside, universal and specific, custom and standard, expert and amateur, nature and artifice, global and local intensified or allayed in the materialization of the smooth glass envelope?

Coincident with postwar industrialization, the treatment of building as an empirical science led to a codification of the processes by which the ideal of precision could ostensibly be materialized. Lorraine Daston and Peter Galison have defined scientific objectivity as an “epistemic virtue,” in that it was generated both by internalizing ethical values and through prescribing practical methods for experimental research. Science devoted to the idea of certainty, as it was from the mid-19th through the 20th centuries, is executed differently from science driven by an ideal of nature, as it was previously.32 Within the context of building research and design, precision became an

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32 Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books; Cambridge, MA: Distributed by MIT Press, 2007), 40-41. Daston and Galison aim to chart a non-teleological history of scientific objectivity to demonstrate how various aspects of the idea of objectivity—such as emotional detachment, automatic data registration processes, and quantification—were somehow combined and defined by a single term which was
epistemic virtue of architecture in the postwar years, as the aesthetic impulse for smooth planar skins and the establishment of environmental standards intersected with the development of curtain wall techniques. This was an episteme informed as much by aesthetic and environmental purpose as it was by the particularities of technical research conducted at academic institutions and by state-sponsored institutes.

Bookended by solid-marble-clad north and south faces, the 39-storey Secretariat tower’s long east and west facades, 544 feet high and 287 feet wide, were of blue-green tinted heat-absorbing glass in a gridded metal framework. In conjunction with Carrier Weathermaster air-conditioning units lining the building’s periphery, these glazed skins created a novel but soon-to-be ubiquitous architectural assemblage: a customizable system of ‘artificial weather’ contained by a taut sealed skin to create an environment intended to maximize efficiency and harmonious relations amongst the workforce. The Secretariat building’s glass facades enveloped a miniature world within which the fledgling institution imagined that minutely calibrated microclimates would produce ideal collaborative conditions for UN delegates and staff, a population with diverse global origins.

Indeed, there was an unresolved tension between holism and reductionism in the UN’s approach to environment and diplomacy. If the Secretariat building purported to

then identified with particular scientific techniques. Ibid., 29-34. According to Karl Popper, a testable universal empirical statement required the existence of a falsifying statement specific to a particular location or condition. This falsifiability produced objectivity. See Karl R. Popper, *The Logic of Scientific Discovery* (London: Hutchinson, 1959), 40-42. This edition was a translation of the German Logik der Forschung, published in 1934, with additional footnotes and appendices not included in the original. While Pietro Belluschi’s Equitable Building in Portland (1947) created a precedent for air-conditioned sealed space, the UN Secretariat was the earliest model of an office tower clad with suspended glazed curtain walls.

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simulate varied global climatic conditions for diplomatic harmony, albeit through the use of American mechanized techniques, the organization itself made environmental politics a focus of international relations, thereby defining the global sphere as something constructed through diplomacy, rather than as a natural entity. Within this framework a component could encapsulate a whole: enclosure details conditioned environmental controls systems; experimental engineering laboratories replicated climates; and a building contained a world.

The design and detailing of the Secretariat’s envelope were therefore instrumental to the material contrivance of a prototypical curtain wall, but also to the delineation of environmental management for the building’s interior. Not only was the Secretariat’s envelope one of the greatest technical challenges of the design process, it also assumed a sizable percentage of the building’s projected cost. Of the $23,760,113.00 total contract price fixed by general contractors Fuller-Turner-Walsh-Slattery (FTWS), $2,165,184 was allocated for the east and west facades, including the aluminum window grid by the General Bronze Corporation, glass by Libbey-Owens-Ford, and all mastics, caulking, and waterproofing. This was one of the largest expenses in the building, exceeded only by structural steel at $2,500,000, and escalators and elevators at $2,500,000. It was therefore essential that the glass curtain walls were carefully detailed to prevent gaps or misalignments that could lead to water and air leakage as well as corrosion. The

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aluminum frames for the glass windows, which projected three feet in front of the building’s steel structural frame, had to be installed with the utmost accuracy, since the large number of windows across each storey of the 287-by-500-foot east and west facades presented the possibility for significant cumulative error across the breadth of the building. Precise installation of each 4-by-12-foot aluminum grid unit was guaranteed through the use of highly accurate surveying methods to position supporting brackets for each grid fragment at the edges of floor slabs. \(^{35}\)

Spurring the advent of the curtain wall industry, the Secretariat’s glass facades were necessarily ad hoc assemblies of components from various manufacturers, thereby functioning as a laboratory for the formulation of a tight glass membrane, the technical development of a new aesthetic ideal [Fig. 1.2, 1.3]. \(^{36}\) As a site for technical experimentation, the development of these glazed skins required laboratory testing of materials and assemblies of components, as well as field observation to examine the impact of complex weather systems—which could not be reliably reproduced in a laboratory setting—upon the newly devised curtain walls. Given the symbolic function of the building, the capacity to realize technical precision in its fabrication was subject to unusual scrutiny. Through its material and symbolic makeup, the Secretariat formulated a model for internationalization in the architectural imagination, while the UN itself developed a model for an institutionalized internationalism. Underlying both the

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\(^{35}\) “A Slender Skyscraper for United Nations Secretariat.” *Engineering News-Record* (Dec. 29, 1949), 20-21. The supporting brackets were in turn bolted to sections of wide-flange beams set into the concrete floor slabs and spaced four feet apart along the width of the façade. A stud welder allowed precise control when attaching bolts to beams to ensure they were exactly on survey lines.

architecture and the institution was a technocratic, bureaucratic sensibility driven by distinctly American managerial ideals, as witnessed in the interactions between the corporations, scientists, research institutions, architects, and engineers involved in materializing the Secretariat’s glass skins. Through their collaborations these parties elaborated a mode of technical precision in building.

The Planning Director for the United Nations Headquarters was the architect Wallace Harrison, whose partner Max Abramovitz was appointed as Deputy Planning Director. Harrison was an adviser to the Rockefeller family, and the firm of Harrison & Abramovitz had worked on the Rockefeller Center complex, which included Raymond Hood’s RCA building. The architects’ enthusiasm for the compelling novelty of an expansive crystalline sheath preceded their concern for its function as environmental enclosure, and early studies of the Secretariat’s glass curtain walls emphasized the visual effects of the material composition. Evocative renderings of the headquarters scheme produced by Hugh Ferris for early design presentations showed the Secretariat as a shadowy form with a roughly indicated gridded façade [Fig. 1.4].

In September 26, 1947 Harrison presented the project before the Ad Hoc Committee on the UN Headquarters, showing a sketch depicting a fragment of a smooth-faced tower with a gridded window wall, and a calculated light penetration depth of 1.5 times the height of the window head: “We have in the Secretariat 4400 people who have to work in offices. That is the first problem we face. We must make those offices as efficient as we can, well lighted, air-conditioned, and treated against reverberating of

37 The Rockefellers purchased the site for the U.N. Headquarters and donated it to the city of New York.
sound [Fig. 1.5].”  

Within the Harrison Abramovitz office, between 1947 and 1948 one young architect, Paul Pippin, was busily exploring a range of façade options through three-dimensional study models. A central conceit of the studies was that both the masonry North-South walls and the glazed East-West facades would be designed to demonstrate that they were thin “veneered skin” rather than load-bearing walls. For this reason both glazed and stone veneers were set back from the corners of the building, in an attempt to emphasize their distinction from corner load-bearing columns, though Arthur Drexler would later argue that this treatment of the veneers disrupted what might have been a more purely planar abstract form [Fig. 1.6, 1.7].

Pippin’s study models showing the entire building mass examined options for the configuration and proportion of the aluminum framing grid, as well as various means of articulating the mechanical floors interspersed throughout the height of the building and the plant penthouse. Some showed more pronounced relief between glazing and framing, while others had a more shallow depth of framing members to create a smoother facade surface [Fig. 1.8, 1.9, 1.10, 1.11, 1.12]. His studies of façade fragments, made with layered colored paperboard and Plexiglas, tested different compositions of tinted, clear,

and opaque glass at windows and spandrels, comparing configurations with varied emphasis of horizontality or verticality within the framing grid [Fig. 1.13, 1.14]. The architects used these façade studies to determine which material configuration would best express that desired quality of hovering flatness in the building’s veneered skins. Here, compositional accuracy was vital to the outward manifestation of planar smoothness made technically possible by a novel suspended curtain wall system.

On November 18, 1948, Harrison, Abramowitz, and Construction Coordinator James Dawson—a former Robert Moses acolyte who became a UN employee for the Headquarters project—supervised the construction of a four-storey mockup of the Secretariat’s façade on the roof of a building on 42nd street in Manhattan. Fifty feet high and eighteen feet wide, and supported by pipe scaffolding, the mockup with pale blue translucent glass spandrels was erected for the purpose of studying the effects of daylight on the material composition. How these shadows and lines appeared would in turn affect the way in which the façade was perceived as a whole. The greater the relief, or the depth between mullions, framing, and glass components, the more the façade would read as an articulated and subdivided plane; the shallower the relief the more it would appear as a smooth and integral skin. Max Abramovitz explained, “We’re checking the shadows and lines, then observing how it looks from two to three hundred yards...We may tear it down in time and redesign the detail.”

While Harrison and Abramovitz were always convinced that the Secretariat should be a taut, flat slab, Le Corbusier who was a member of the international committee of consulting architects, adamantly opposed the smooth glass envelopes

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designed for the building’s east and west facades. Instead, he suggested the application of mobile vertical and fixed horizontal louvers outside the external line of the glass for optimal solar control.\textsuperscript{42} While Le Corbusier insisted that an unshaded glass skin would produce an overheated interior and perilous working conditions, Abramovitz countered that interior venetian blinds combined with air-conditioning would be a more economical and efficient solution.\textsuperscript{43} After Le Corbusier complained to Senator Warren Austin, the United States Ambassador to the United Nations, that the glass curtain wall favored by

\textsuperscript{42} The design committee selected a scheme for the Headquarters which combined aspects of Le Corbusier’s scheme with elements from Oscar Niemeyer’s scheme; both schemes showed the Secretariat as a skyscraper situated next to a low-slung General Assembly building, although Niemeyer’s scheme incorporated more open park-like space by fully separating the General Assembly from the Secretariat and reducing its mass. For a description of the design process see George A. Dudley, \textit{A Workshop for Peace: Designing the United Nations Headquarters} (New York: Architectural History Foundation; Cambridge, MA: MIT Press, 1994), and Victoria Newhouse, \textit{Wallace K. Harrison, Architect} (New York: Rizzoli, 1989). Vladimir Bodiansky, Le Corbusier’s associate in the Atelier des Bâtisseurs (At.Bat.), was appointed as an “expert collaborator” on the technical committee convened to address problems of sun control in relation to air conditioning at the Secretariat, and also recommended louvers. For a description of Bodiansky’s work see Christel Frapier, “The Career of Engineer Vladimir Bodiansky,” \textit{Engineering History and Heritage} 165, 2 (May, 2012): 113-121.

Harrison and Abramovitz would lead to a “veritable technical catastrophe,” Harrison convened a committee of experts to “tell us what the absolutely scientific answer is to this question,” and the consensus favored smooth glazed skins.

This controversy concerned the technical means of environmental containment, but very clearly also the aesthetic desire for suspended, hovering, planar facades. More importantly, the dispute indicated the ways in which the bureaucracy of the UN would be harnessed to resolve technical and aesthetic problems in the realization of its own architectural icon. The conflict between Le Corbusier and Harrison & Abramovitz was perhaps a harbinger of the way design processes would come to be dominated by corporate interests in the development of subsequent large-scale office building projects, but it also indicated a flexible use of “technical knowledge,” for while each of these


architects used claims of economy and efficient performance to support a preferred external form, the technical aspects of both schemes were only cursorily calculated. By contrast, the technical calculations, research, experimentation, and testing performed throughout the actual construction process were executed with the express aim of maximizing economic, aesthetic, and environmental precision. Indeed, the drive to precision distinguished the material resolution of the building skins from the debates surrounding their initial design, which had more to do with a particularly American impulse towards smoothness in conflict with a (some might argue European or even “international style”) preference for the plastic form of brises-soleil. In the resolution of the Secretariat’s glass skins, then, we witness a turn from the classifications of the “international style” to a conception of internationalism shaped by American innovations in materials science and air-conditioning to form slick abstract slabs which could accommodate a bureaucratic and increasingly economically-centered civic and global imaginary.

**Envelope as Experiment**

The final design for the curtain wall composition was distinctively flat, with expressed vertical mullions and suppressed horizontal mullions. Dedicated floors for plant capacity were clad with a metal louver system, and rooftop mechanical equipment was concealed behind an extension of the glazed skin. For all exterior glazing on the east and west facades above the first story entrance, except for the penthouse, each storey comprised an eight-foot-high strip of glass composed of double-hung windows in blue-tinted ¼” heat absorbing polished plate glass by Libbey-Owens-Ford and glazed spandrels of blue-tinted
¼" heat absorbing Aklo polished wire safety glass with a welded fabric mesh pattern manufactured by Blue Ridge, a subsidiary of Libbey-Owens-Ford. These spandrel panels were set in front of black-painted cinder block backup walls, which made them appear to be a darker hue than the windows and created a contrasting horizontal pattern at floor levels. Narrow strips immediately above the glazing, which housed spring balance boxes for the double-hung windows, were clad in aluminum. The aluminum framing grid was designed with deeper members only at horizontal floor levels, but at each window panel width vertically, to achieve an articulation emphasizing thin vertical strips stretching the height of the Secretariat tower, sitting just in front of, and in contrast to, the horizontal bands of tinted window and spandrel glazing [Fig. 1.15].

The final set of design drawings, produced in September of 1948, showed the ¼" tinted plate glass panes of the double-hung windows held in place by stainless steel spring glazing clips, which were filled in with glazing putty to further secure the panes and to provide a weather seal. Mastic was also used to seal the aluminum cladding bands

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48 See Pippin, A Design Assignment for history of design studies on the articulation of east and west window walls.
where they interfaced with spandrel and double-hung glazing.\textsuperscript{49} The following month the drawings were amended to include weep holes at the bottom edge of spandrel glazing [Figs. 1.16, 1.17, 1.18, 1.19, 1.20].\textsuperscript{50}

Once the façade composition was determined, Fuller-Turner-Walsh-Slattery (FTWS), the general contracting corporation comprising four firms of contractors and collectively managed by two representatives from each firm, worked to coordinate the transfer of information between the architects, engineers, glass suppliers, glass manufacturers, metallic façade grid manufacturers, mechanical systems consultants, and mechanical systems manufacturers.\textsuperscript{51} The contracting corporation had been formed based in part on a bid submitted by the George A. Fuller company, which promoted its expertise in large-scale construction, using techniques which the company had developed for wartime projects, including the process of ‘palletizing’ materials to bringing vast quantities of materials to site with little waste of time or motion, strategies for procuring large quantities of steel and other materials in a period of shortage, and the capacity to construct large volume projects with speed and economy.\textsuperscript{52}

In 1882 George A. Fuller had created the modern concept of the general contractor by founding his Chicago firm to handle all aspects of building except design.

\textsuperscript{49} Drawing Sheet A-113, “Typical Window Details,” dated Sept. 27, 1948, United Nations Archives.
\textsuperscript{50} Drawing Sheet R-A-6, “Mullion Supports and Spandrel Details, Revision to A-113,” dated Oct. 25, 1948, United Nations Archives.
\textsuperscript{52} United Nations Archives, S-0472-0004- 01, Office of the Secretary-General, Headquarters Planning, Architects, General, 1945-1948. A brochure from the George A. Fuller Company for building construction includes images of wartime projects they constructed, including air and naval bases, Columbia Steel Company steel works, Dodge-Chicago-Chrysler plants by Albert Kahn, Sinclair Oil power house, the New York state power plant, the “Synthetic Rubber Program” and the “Atomic field.”
Fuller contractors built Rockefeller Center and the Flatiron Building in New York, and later Lever House. The Fuller company’s wartime work included projects for the Navy, the Army, and the mobilization of industry. Industrial projects were completed for the United States Government as represented by the Defense Plant Corporation, otherwise known as “Plancor,” or through direct contract with private businesses.\(^{53}\) As materials became scarcer and buildings had to be redesigned to utilize available materials, FTWS devised new building strategies, including systems for material allotment and construction scheduling based upon material availability. Contractors had to find substitutes for materials and machinery when they were reassigned to higher priority projects in the war effort, and ensure safe and efficient transportation of goods [Fig. 1.21].\(^{54}\) Immediately following the war, upon the foundation of the United Nations, Fuller Company President Lou Crandall sensed a commercial opportunity for both his company and the building materials industry which had greatly expanded to meet the wartime effort: “We in the United States, and the world at large, must live in the hope that human and international understanding, nurtured by this agency, will grow and progress to overtake the advance in the materials sciences we have witnessed and shared.”\(^{55}\)


\(^{54}\) Ibid., 12-16. The procurement of sufficient laborers was an added concern. Following the Dec. 1941 attack on Pearl Harbor “the work for defense became the work for war,” and the pace of construction rapidly accelerated. By 1942 the Fuller company was immersed in an immense emergency war plant construction effort. The demand for basic materials greatly surpassed the capacity of existing production facilities, and losses in the Pacific restricted access to important raw materials. The George A. Fuller company, under the auspices of Plancor, built steel mills in Utah, synthetic rubber plants in Texas, and munitions, aircraft, cable and engine factories throughout the United States. See Ibid., 151.

\(^{55}\) Ibid., 193. Lou R. Crandall was president of Fuller-Turner-Walsh-Slattery, and he was president of George Fuller Construction Company in New York from 1928-1957.
telling in Crandall’s statement was the way he framed the business of building science as a platform for the global transmission of a democratic ideal; material innovations held value not simply for the ways they enhanced the technical performance of buildings and machinery, but also for their capacity to represent a new international order in which technological advancements could buttress humanitarian programs.

This expanded building materials research network, composed of scientists, academic institutions, industrial manufacturers, and military research projects, was a critical resource for FTWS in its work to coordinate the construction of the Secretariat, and particularly to maximize accuracy in the realization of its glass envelope. In March 1949 FTWS called upon one member of this network to carry out an independent investigation of the aluminum window grids for the east and west facades of the Secretariat building. Dr. Herbert Uhlig, Head Metallurgist at MIT, was recruited to consult on detailed cross section drawings of the window construction. According to Uhlig, the major perils of such a wall composition were electrolysis, corrosion, and the freezing of metals. For points of attachment between aluminum and steel he recommended bituminous paint, and for points of contact between aluminum members he suggested that surfaces should be painted with mastic to avoid the risk of water entry and resultant corrosion. Uhlig also conferred with his colleague Albert G.H. Dietz, Associate Professor of Structural Engineering at MIT and an expert on plastics, regarding caulking compounds and materials.\textsuperscript{56} Dietz confirmed that standard glazing putty would have no negative effect on the aluminum, but also promised to research superior putties.

Following Uhlig’s suggestions, FTWS advised the United Nations to proceed with the original bid drawings submitted for the façade design, but to provide caulking over areas where aluminum mullions slid over jambs, to prevent water-induced crevice corrosion.\textsuperscript{57}

In late June of 1949 FTWS consulted Albert Dietz directly for guidance on sealing the glazed east and west walls. Regarding the sealing of aluminum mullions between glass panes, Dietz advised using a stiff “gun consistency” mastic like those produced by Tremco Manufacturing Company, an Ohio-based producer of sealant and weatherproofing materials for building construction. Dietz had discussed this in depth with Gordon Hann and Carl McNamara of Tremco, who assured him that “[t]his joint can with a mastic which will not sag unduly be filled.”\textsuperscript{58} Due to the large volume of mastic in relation to the exposed surface of aluminum, the mastic compound was projected to remain soft for a number of years and require infrequent maintenance or replacement.\textsuperscript{59}

Dietz recommended that fixed spandrel glass panels be set in an extruded neoprene channel, “which should retain its resilience over a long period of time.”\textsuperscript{60} A potential problem still lay in how watertight the neoprene channel seal could be, as it

\textsuperscript{57} Letter from Lou Crandall, president of Fuller-Turner-Walsh-Slattery, to James Dawson, 3/8/49. United Nations Archives, S-0472-0006-01, Office of the Secretary-General, Headquarters Building Construction, Working Project Foundations and Secretariat Building, Fuller-Turner-Walsh-Slattery, Inc., 1948-1949. In addition, the contractors advised against making window units removable, and against amending the spandrel design to create a separate sash and frame, with weatherstripping: “This is mainly a matter of economy and that the interest and amortization of the principal invested would allow more than sufficient funds each year than would be necessary for the extra work involved to change this glass.”


\textsuperscript{59} Ibid. Dietz also advised on the gaskets between marble panels on the north and south facades.

\textsuperscript{60} Ibid.
interfaced with both glass and aluminum frame. Dietz projected that the neoprene seal would outperform the stainless steel glazing spring on the original drawings, but acknowledged that driving rains might force water past the neoprene channel; to thwart this possibility he recommended a bed of mastic between the neoprene channel and aluminum frame. Condensation on the interior face of the glass was a strong likelihood, according to Dietz, so weep holes would be a crucial means to transmit water back outside.61 Finally, regarding the sealing of the double-hung windows, Dietz again advised neoprene channels in conjunction with a glazing compound, rather than the stainless steel spring clips shown in the drawings, which he deemed likely to squeeze any glazing compound aside, thus rendering the bed of compound too thin and prone to rapid hardening and subsequent cracking.62

There would have been little time to incorporate Dietz’s recommendations, as by July 1, 1949 production of the aluminum window walls was well underway at General Bronze’s Garden City, Long Island plant, where all extruded aluminum components, all miscellaneous steel members, all hardware, and all cast aluminum sills were already on site. Thirty five percent of the bent plate aluminum mullions were also on hand, with weekly shipments on schedule.63 A 24-foot-high by 8-foot-wide sample panel consisting of two complete units of each type (double-hung for standard floors and louvered projecting window for pipe gallery floors) was to be finished by July 8. The four units

61 Ibid.
62 Ibid.
were to be clipped together and stud welded to 5-inch I-beams similar to the mullion anchors being erected on the Manhattan building site. Incorporating all the hardware, glass, and stainless steel flashing specified in the drawings, this mockup panel would demonstrate any glitches in the erection process, and would also be used for a visual inspection by the United Nations architects and FTWS.\footnote{Ibid.}

With plans for the first floors of glass cladding to be erected on the job site on July 15, 1949, and an accelerated production schedule of two and a half floors per week, the rate at which the window walls were materialized far outpaced the capacity of the architects, contractors, and manufacturers to fully understand the limits of their performance [Figs. 1.22, 1.23, 1.24]. Despite consulting Dietz and Uhlig on the intricacies of the aluminum and glass façade assembly, and despite the fabrication of mockups to check for errors in construction processes and for final visual analysis, the physical and environmental efficacy of this incipient curtain wall was a matter of conjecture. Once the glass envelopes were materialized, the material precision configured through preliminary sketches, models, façade studies, detail drawings, engineering calculations, and mockups would be tested against the spatial and atmospheric conditions unique to a 39-storey building on a midtown-Manhattan site. The Secretariat’s skins were therefore quite literally a site for technical experimentation, demonstrating principles of material and environmental construction that could not be gleaned from standard means of testing and representation. In part because the single-pane glass windows of the Secretariat’s planar walls were not pressurized, with an equalized air space between inner and outer weather seals, the tightness of the membrane relied upon the strength of sealant
materials. While the internal mechanical system operated reliably, the component of the contained environment that began to fail was the seal itself.

**Technical Error: An Exercise in Precision Redefined**

Shortly after UN employees began to occupy the Secretariat building, a series of unusually powerful storms in 1950 and 1951 damaged windows on the east and west facades, prompting the *New York Times* to declare: “A few leaky windows can be a housekeeping headache when there are 5,400 of them in a single structure...” [Fig. 1.25].

Manhattan’s landscape of towers created unusual topographical conditions, due to which high air pressure on the windward side and low air pressure on the leeward side forced air against skyscraper walls with unusual power. At issue was whether the same calculations performed for smaller structures could accurately predict the effects of wind and rain on an unprecedentedly large-scale glass envelope. Incorporating the type of detailing conventionally used for smaller buildings on a structure the scale of the Secretariat carried the risk of leaks. The extremely large glass surfaces were also exceptionally, exaltedly flat. Window glazing was set a mere four inches from the outer edge of the façade’s aluminum framing, thereby laying it open to hazardous leaking.

To ascertain the cause of the Secretariat leaks, the architects and engineers called on experts in mathematics and aeronautical engineering, who explained that the façade’s large dimensions exponentially intensified the air pressure against the expansive glass skins. Moreover, the more oblong a building’s form, the more pressure per square foot

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66 “Beating the Leaks in a Glass and Metal Wall Like the U.N.’s.” *Architectural Forum* 95 (June 1951), 204.
would be cast against its façades [Fig. 1.26]. The very nature of the slab building form thereby led to increased air pressure against its envelope. As a result of this heightened air pressure at the Secretariat, leaks in the broad east and west facades admitted soot, drafts, and rain. For the UN employees in wet workspaces the issue was certainly an environmental problem, but it was also a question of image, as the Secretariat building had become an internationally recognized example of advanced construction techniques. Any technical failures were used as ammunition for detractors of modern building, whose "snide criticism" architect and critic Henry S. Churchill saw as a continuation of the gleefully dismissive commentary over Frank Lloyd Wright’s leaky roofs.

More insidiously for the UN, as a public relations disaster at an architectural-scale, the building’s leaky glass walls could be hyperbolized to indicate technical ineptitude on the part of an institution whose developmentalist programs were steeped in the rhetoric of technocracy. The institution’s predecessor, the League of Nations, was shaped by the “imperial internationalism” of the late 19th and early 20th centuries, which combined the economic imperatives of empire with worldwide cultural dissemination. As the 1927 design competition for the League of Nations headquarters revealed, the symbolism of this international order was caught up in a European ideological schism between the 19th century academic Beaux Arts tradition and various strains of modernism. When the

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67 Ibid., 205.
League was transformed into the UN following the war, a kind of scientific ecumenism was applied to create a policy environment led by technical and scientific experts who were presented as neutral actors solving practical problems, indifferent to political strategy. In contrast to the League of Nations the UN adopted a more American, bureaucratic direction, less powerful as an adjudicator of international law than as the implementer of technical programs for economic and social conversion worldwide, through which it hoped to crystallize a global body of sovereign nation-states linked by common purpose and a mutual interest in economic expansion.  

Endeavors like the United Nations Scientific Conference on the Conservation and Utilization of Resources (UNSCCUR) were contrived to provide a forum for exchange between experts, including scientists, engineers, economists and sociologists to foster greater international cooperation on resource protection, which the UN presented as integral to its peace-keeping mission. Held in 1949, just as Uhlig and Dietz were

71 Mark Mazower, *No Enchanted Palace: The End of Empire and the Ideological Origins of the United Nations* (Princeton, NJ: Princeton University Press, 2009), 191-194. Following the war, when Europe’s world standing was diminished, the United States and Britain spurred the transformation of the League of Nations into the UN in 1946. Since the United States exceeded other nations in funding the UN, as well as in supplying staff, it was not always clear where the boundaries between American and other national initiatives lay.

72 *International Union for the Protection of Nature, Established at Fontainebleau, 5 October, 1948* (Brussels: M. Hayez, 1948). UNSCCUR was planned to coincide with the International Technical Conference for the Protection of Nature, and was jointly sponsored by the International Union for the Protection of Nature and UNESCO. In a 1946 letter to US Representative to UNESCO John Winant, President Truman outlined the aims of a United Nations Scientific Conference on the Conservation and Utilization of Resources (UNSCCUR), planned for 1949, in which resource conservation was inextricably linked to the UN’s internationalist ideology and the global development programs it implemented in the years following the Second World War: “The real or exaggerated fear of resource shortages and declining standards of living has in the past involved nations in warfare. Every member of the United Nations is deeply interested in preventing a recurrence of that fear and of those consequences. Conservation can become
advising on the technical details of the Secretariat’s enclosure, UNSCCUR was intended to have an “essentially scientific character.” While the UN presented industrialization processes as inevitable agents of modernization, it advocated proper management to prevent environmental destruction. In promoting the use of by-products as well as resource recuperation and substitution, the conference would give special attention to “under-developed areas,” coalescing the “technical knowledge” of the previous decade to be directed towards research, design, and production problems of industrializing zones.

Through such technical initiatives, the United Nations operated from its inception as a channel for American diplomacy in the Cold War era. New Deal programs like the Tennessee Valley Authority were widely seen as evidence of America’s great skill in applying technical expertise to agriculture, industry, public health, and urban planning, all the while demonstrating the potential of democratic capitalism to address the collective good through management and planning. The United States saw in the UN an instrument to combat Soviet influence worldwide, with programs for technical training


75 See Tony Judt, *Ill Fares the Land* (New York: The Penguin Press, 2010), 56-58. The “total war,” which involved whole nations in the collective project of mobilization during WWII, was transformed following 1945 into a new era in the US and Western Europe which was characterized by “planning” and a bureaucratic order applied to economics and infrastructural projects.
and industrialization within emerging economies, especially in Asia, to complement its more overt anticommunist military campaigns.\textsuperscript{76}

Through United Nations programs, the foreign policy of United States was able to assume what Mark Mazower has called a kind of “ambidextrous” internationalism, in that it was able to operate both unilaterally and multilaterally as required.\textsuperscript{77} President Truman’s Point Four program of technical assistance to foreign nations, which he presented in his January 1949 inaugural address, was intended as a transition away from direct monetary aid to foreign nations. Instead, this program, coordinated by the United Nations, would export the “imponderable resources in technical knowledge” of the United States to support scientific and industrial growth worldwide.\textsuperscript{78} Truman linked scientific industrialization to global harmony, stating: "Greater production is the key to prosperity and peace. And the key to greater production is a wider and more vigorous application of modern scientific and technical knowledge."\textsuperscript{79}

At the same time, Truman’s Point Four program framed the national interests of the United States in terms of global development. Political instability in Europe was no longer the primary threat to American security; now the expanding populations in emerging Asian economies had to be controlled. Through technical assistance programs, former European empires would be knocked down and replaced by bureaucracies of technical experts who would remake the colonial East in the American democratic and

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\textsuperscript{77} Ibid., 277.
\textsuperscript{79} Ibid.
\end{flushleft}
The UN helped to concretize this new world order predicated upon the dissolution of empire, in which Britain and Europe no longer dominated and Afro-Asian member states grew in number and voice. Economic development through the exportation of scientific and technical expertise—as in the techno-developmentalist programs sponsored by the United States and the United Nations—was one means to counter the Anglo-American dread of being conquered by the swelling eastern masses.

It is not overstating the matter to suggest, then, that the UN’s capacity to effectively implement global development programs, especially in vulnerable emerging economies of the East, and to thereby preserve a techno-capitalist system dominated by the United States, depended at least in part upon the precise composition and functioning of its most closely held technical program, the headquarters being constructed in New York City. There, the accurate resolution of a curtain wall system’s flaws, made obvious only after it was fully materialized, assumed the burden not only of legitimizing a novel construction system, but also of symbolically registering the UN’s mission to administer technical knowledge.

The United Nations Headquarters Planning Office, in collaboration with the consulting engineers, contractors FTWS, and General Bronze, had devised a series of untested curtain wall techniques that were largely reliant upon new materials. Each successive sketch and detail, drawn at an increasingly magnified scale, further refined the

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80 Ibid. Truman stated in his speech: "The old imperialism-exploitation for foreign profit has no place in our plans. What we envisage is a program of development based on the concepts of democratic fair-dealing."

81 Mark Mazower, *No Enchanted Palace*, 152, 185. Mazower explains that as the UN continued to settle disputes between commonwealth member states it solidified its stance against imperialism, motivated by politics rather than by international law.

components in this layered composition in order to resolve the problem of leakage. When initial envelope failures led to a protracted design process, it became clear that precision did not simply pertain to the Secretariat’s clean, technical, geometric aesthetic; precision was also key to the way in which the building’s skin would be constructed and read from the inside out. In other words, to create the image of technical fidelity within the building’s envelope would require a novel approach to its fabrication. This was partly true in the literal sense of the material composition, in that accurately sized and assembled components would create clean lines on the envelope’s exterior. More importantly, however, the thin flat skin specified by the architects, with minimal framing members set nearly flush with the glass, contained specific environmental repercussions. The final line of defense against leaks was not in fact the large sheets of glass forming an intermittently reflective surface, but instead the barrier lay in the arrangement of components to equalize pressure, drain out moisture, and minimize corrosion. The aesthetics of architectural precision necessarily required new levels of exactitude in the separation between inside and outside space, but these materials and compositional methods of environmental containment were all but invisible to the casual observer.

To resolve the condemned leaks in the Secretariat’s glass envelope, in 1951 FTWS called on Professor Walter C. Voss, Head of Building Engineering and Construction at MIT and an expert in new building materials, who had previously advised on the use of silicone caulking for the building’s north and south facades.\(^3\) Voss built a “pressure

box,” with a typical Secretariat window wall section forming one side, as a testing apparatus to determine the behavior of the existing glass under various weather conditions. He increased air pressure inside the box to simulate different wind speeds, and introduced water to simulate precipitation. Apparently only submarine windows had ever been tested so thoroughly. Voss deduced that at very high velocities water leaked through the Secretariat’s glass walls at the head, sill, and meeting rails of the double hung windows. Stainless steel weatherstripping proved faulty, perhaps due to damage incurred when dirt particles dented the material during installation, or possibly from soot and cinders blown in from a nearby power station. He recommended the initial remedy of replacing stainless steel flashing with weatherstrips of neoprene, a relatively new material he expected to last for at least 15 years. To this he added a sill gasket on the inside face of the glass, and a head gasket on the outside surface of the window head, to absorb any water driven upwards in high winds.

Prof. Dietz’s advice to include a neoprene channel in the spandrel glass setting

consultation with Prof. Walter C. Voss, Head of Building Engineering and Construction at MIT, who recommended caulking expansion joints with Silicone of Kuhls Caulking Compound in addition to mortar to protect against possible movement of expansion joints between floors: “Silicone is a comparatively new plastic material and its aging qualities unknown to us. However, we are making further investigation of these various caulking compounds and will report the results of our findings to you when they become available,” 3.

84 “Beating the Leaks,” 212.
had evidently been ignored. Discontinuities within both caulked expansion joints in spandrel flashing and putty glazing admitted water to the building interior.\(^{86}\) Water entered through the unusually large weep holes at the bottom of the spandrels, which were devised for superior drainage and to equalize the temperature between the outside air and the wall cavity, preventing cracking in spandrel glass. The backup wall and balance box of the spandrel glazing had been designed with flashing to keep out water that drained down the wall, but the detail did not prevent the seepage of water pushed \textit{up} against the glass. Rather than weeping out again, water seeped inwards instead, flooding over the head of the spandrel and leaking through balance screw holes that had been left open for the purposes of observation.\(^{87}\) Voss suggested including a section at the base of the spandrel to serve as a baffle so water could no longer be driven up through weep holes, providing a two-inch buffer zone for any water that entered the spandrel portion of the wall [Fig. 1.27].\(^{88}\)

Throughout 1951 and 1952 the contractors, architects, and General Bronze developed a number of techniques to render the façade watertight, including adding aluminum cover plates at mullion expansion joints; sealing weep holes using baffles or plastic closures; and adding aluminum retaining angles at the ends of spandrel panels.\(^{89}\) General Bronze produced a model that incorporated all of these strategies and submitted it to water and wind tests at their Long Island plant, where the testing apparatus included


\(^{88}\) “Beating the Leaks,” 212.

\(^{89}\) Letter from Grogan to Dawson dated 6/2/52. United Nations Archives, Ibid.
an airplane engine to blast air and water at full-scale mockups of the window wall [Fig. 1.28]. The sketches produced by General Bronze in the spring and summer of 1952, done in graphite pencil on vellum paper, were large-scale detail drawings describing the application of additional flashing and waterproof coatings. Unlike the façade study drawings produced by Paul Pippin in the Harrison & Abramovitz office, which were intended to express the composition of mullions and spandrel framing, these sketches studied the internal configuration of components required to effect the smooth, flat, gridded composition that the architects desired. A General Bronze sketch showing “Proposed Spray Coating Behind Mullions,” drawn on May 8, 1952 and revised on July 14, 1952, detailed the application of “Plastispray” over all structural mullions, and air-dry neoprene at all expansion joints occurring at aluminum mullion covers [Fig. 1.29].

Plastispray was a vinyl chloride-vinyl acetate copolymer, transported to the site in liquid form and applied using a high-pressure spray gun to form a flexible plastic skin with high tensile strength and good adhesion, able to withstand all structural movement. It was described in 1954 by an architectural consultant to two major plastics companies as “the answer to the age-old problem of the joint in construction.”

90 Letter from Dawson to FTWS dated 6/4/52. A subsequent letter from Grogan of FTWS to Dawson, dated 6/9/52, states that a test for the proposed methods for improving the watertightness of the Secretariat facades will be run on 6/17/52 at the General Bronze plant at Garden City, Long Island, and asks the UN to send a representative to monitor the tests. United Nations Archives, Ibid. See also “Beating the Leaks,” 212.
indicating its location in the General Bronze sketch failed to express was its pliability; together with neoprene, this new plastic application had the flexibility necessary to fill in the inevitable gaps of a multilayered wall composition, which would expand and contract and shift over time.

While early renderings and façade studies of the Secretariat might have been intended to demonstrate consummate technical skill in the building’s material and linear composition, they were meant to be read subjectively, emphasizing the building’s planar slab form in relation to the headquarters complex and to the city at large. The technical perfection alluded to in these images was more an expression of a cultural impetus than any measureable property. The detail drawings, on the other hand, were produced for the purposes of inter-professional exchange between architects, engineers, manufacturers, and technical specialists, and they contained seemingly objective information. Here the technical was defined by performance, although it certainly also pertained to the image of the building that the architects had specified. The shift from subjective to objective readings in various representations of the Secretariat’s glass surfaces indicates the confusion between these categories when the image of technique transformed from description to prescription. The perplexity of subjectivity and objectivity in the technical development of the Secretariat’s glazed skins prefigured a problem endemic to the architecture of enclosure throughout subsequent decades.

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complete change of almost all concepts of our present-day construction technology…Designing with sprayed plastics affects structure, mechanical systems (including heating and air conditioning), the selection of materials, the assembly of materials, and color schemes.”
Ultimately, the measures taken by General Bronze and the United Nations Headquarters Planning Office were insufficient to prevent leakage in the Secretariat’s window walls, so the contractors called on the services of Elmer Queer, an expert on waterproofing and Professor of Engineering Research at The Pennsylvania State College School of Engineering. Queer had served the US Navy during the Second World War, developing dehumidification techniques for preserving ships and military materials. In the autumn of 1952 Queer outlined a plan of remedial work on the Secretariat’s leaking facades, which included installing aluminum corner angles and expansion joint covers on mullions, and closing two thirds of all weep holes with neoprene grommets, securing flashing at head panels with clips and sealants, and installing tarred oakum fiber at roof and show window head levels. Queer also suggested that vapor-resistant protective coatings of synthetic Insul-Mastic films and caulking compounds would produce tighter seals than the older mastics, putties, and caulking compounds by Pecora Paint Company. FTWS were satisfied they had elicited first-rate technical expertise. In a

93 National Research Council (U.S.) Building Research Institute, Metal Curtain Walls. The edited papers and discussions of a research correlation conference conducted by the Building Research Institute in the Chamber of Commerce of the United States in Washington, D. C., on September 28 and 29, 1955 (Washington, DC: Building Research Institute, Division of Engineering and Industrial Research, National Academy of Sciences, National Research Council, 1955), 123.

94 Letter from Queer to UN dated 10/17/52. United Nations Archives, S-0472-0013-04, Office of the Secretary-General, Headquarters Building Construction, Working Project, Foundations and Secretariat Building, Fuller-Turner-Walsh-Slattery, Inc. 1951-1953. Queer recommended that the work should be postponed until the summer of 1953, when it could be performed in warm weather. Tarred oakum was used in shipbuilding to seal vessels. It can be made of raw hemp or jute, but was traditionally made from unraveled used rope. In Victorian Britain, prisoners and poorhouse workers typically carried out the painstaking work of picking oakum; this labor generated the materials to fabricate the ships that maintained and expanded the empire. During the postwar period oakum was gradually replaced by synthetic rubber sealants.

95 Letter from Queer to J.J. Healy of GB, dated 11/24/52. United Nations Archives, Ibid.
letter to Harrison & Abramovitz architects, President Crandall pronounced, “this building, I believe, will be watertight in the sense that any well built building in New York City is watertight.”96 In the autumn of 1953, three years after it opened, Professor Queer declared the Secretariat properly sealed, and a New York Times article lauded the contractors and engineering consultants for their “‘pioneering work’ in the field of modern building.”97

The Institutionalization of Building Research

The procedures used to render the Secretariat building watertight offered a practical model for the design of glass and metal envelopes that many viewed as a guide to save architects and their clients thousands of dollars in averted missteps on future construction projects.98 In that sense, the Secretariat operated as an object lesson in technical experimentation for the burgeoning American building research network. The agents involved in fine-tuning the Secretariat’s envelope—including Queer, Dietz, Voss, and Uhlig—were beginning to codify the production of both tightly enclosed regulated environments and the smooth surface of postwar modernism. As curtain walls

96 Letter from Lou R. Crandall to L.S. Abberley dated 3/3/53. United Nations Archives, Ibid. A report from Wallace Harrison dates March 10, 1953 states that the UN will cover $30,000 of the costs of remedial work to the east and west facades of the Secretariat “to prevent infiltration of water,” and that the remaining funds in a sum estimated to be at least $120,000 must be covered by the contractor, Ibid.
98 “Beating the Leaks,” 204. The article quotes a “very famous architect” as saying that “‘I’m profiting by the UN experience to save my own client a great deal of money.’”
proliferated in the United States, building science emerged as a distinct field, with an expanding research network encompassing academic architecture and engineering departments, building products manufacturers, and state-funded research divisions. Beginning in 1954, the Building Research Institute (BRI) of the National Academy of Sciences Research Council organized conferences on new building techniques, where representatives from the steel, glass, chemical, and building products industries convened with architects and engineers to exchange expertise [Fig. 1.30].

The engineers who consulted on the Secretariat’s envelope were active participants in this research community. Elmer Queer spoke at a 1955 BRI conference on metal curtain walls, where he was introduced with the commendation: “‘No one actually knows what goes on inside the wall, and Professor Queer knows much more than anyone else.’” Queer spoke on fragmented wall compositions, in which numerous conjoined components created opportunities for thermal by-pass between a wall’s structural members, both in joints between materials and at points of attachment to the building. With the prevalence of air-conditioning and rising energy costs, vapor-tight structures were in high demand. To manage the latent load on a building’s cooling system, and to prevent water from entering wall cavities, joints between components and flashing had to be “effectively tight.” To resolve these issues, accounting for variable expansion and contraction of components due to temperature and humidity changes, Queer advocated

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99 Topics included: metal curtain walls, plastics in building, cleaning and purification of air in buildings, modular coordination, and adhesives and sealants in building.
100 Quotation taken from a letter sent to the BRI by the president of the Erie Enameling Company. National Research Council (U.S.) Building Research Institute, Metal Curtain Walls, 123.
101 Ibid., 124.
102 Ibid., 128.
standardized testing procedures, the major challenge for which was to simulate realistic atmospheric conditions.\textsuperscript{103} While heat-transfer measurement procedures had been regulated, existing laboratory procedures to analyze moisture and thermal conditions in curtain wall assemblies had yet to be systematized.

To test the performance of the Secretariat’s glass walls Walter Voss had used a provisional pressure box at his MIT lab, in which a mockup fragment of the glass façade formed one side of a chamber whose interior was subject to increasing pressure and moisture content. At the 1955 BRI conference Queer named the Climatometer at Pennsylvania State College’s Engineering Experiment Station as a prototype for a standardized testing apparatus [Figs. 1.31, 1.32, 1.33]. Described as an “all-weather room,” the Climatometer was designed to test the performance of materials, structures, and machines under extreme weather conditions, from arctic to tropical. There, wall fragment mock-ups of 8 by 2 to 4 feet were sealed in a highly insulated cell and analyzed by instruments designed to gauge material temperatures ranging from -60 to 130 degrees F, as well as variable humidity in cycles mimicking diurnal rhythms.\textsuperscript{104} Commandeered by the Office of Production Research and Development of the U.S. War Production Board, the Climatometer was originally used for tests to establish standards of performance and specifications for navy ships and army equipment under widely fluctuating atmospheric conditions. Because the performance of new synthetic materials in extreme climates was unknown, the Climatometer was used for expedited weathering

\begin{footnotesize}
\textsuperscript{103} Ibid., 129.
\textsuperscript{104} Pennsylvania State College, Department of Engineering Research, \textit{The Climatometer, an All-weather Room Designed to Provide Controlled Temperatures and Humidities Simulating all Conditions from Arctic to Tropic for Determining the Performance of Materials, Constructions, and Machines under Extreme Conditions} (State College, PA: Engineering Experiment Station, Pennsylvania State College, 1944).
\end{footnotesize}
tests to ascertain the durability of gear such as synthetic raincoats and sleeping bags to outfit the U.S. troops dispersed across the globe [Fig. 1.34]. By the close of the war, Penn State began to advertise the Climatometer for peacetime industrial applications.

Voss himself argued for standardized dynamic tests on large structures at a subsequent BRI conference on *Adhesives and Sealants in Building* in 1957, positing that these tests afforded the opportunity to address sealant discontinuities, as had occurred during the design of Mies van der Rohe’s Seagram building, where leaking miter joints discovered in prototype testing had been resolved by reinforcing the joints with Thiokol synthetic rubber. Voss was retained as a construction consultant on several notable projects, including SOM’s Connecticut General Life Insurance Building, which was presented as an example of the design potential of metal curtain walls in a 1959 BRI conference. On that project, Voss and the design team spent a year studying and testing material components of the aluminum-framed heat-absorbing glass facades, as well as heating, air conditioning, and solar control, to meet the client’s demand for a building with the “most up-to-date technology” and requiring as little maintenance as possible.

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105 “Arctic, Tropics, Come to Penn State, Professor Does Anything He Wants with Weather, Makes It Hot, Cold, Wet, Dry, Windy, Calm to Test Various Equipment for the Army,” *The Pittsburgh Press* (July 27, 1944), 16. "The climatometer has perhaps saved thousands of men from discomfort or even from death by telling in advance the weakness of a new type of equipment to be issued." 
Voss set up tests to analyze the weathering of aluminum, stainless steel, synthetic rubber gaskets and sealants, and to examine capacity of heat-absorbing plate glass to resist wind pressure and thermal shock. He also tested the elasticity and imperviousness of gaskets and sealants in his MIT laboratory, where the materials were placed in a Weatherometer and a Fadometer to see how they responded to freezing and thawing, water immersion, salt sprays, and ultraviolet light. Voss concluded that the Connecticut General building’s envelope would have a lifespan of 65 to 70 years. Following lab tests, a full-scale mockup of the glass wall was erected at the manufacturing plant and subjected to dynamic testing, which simulated 120 mile per hour winds and heavy rain; the mockup deflected up to 2” but did not leak or crack.\textsuperscript{108} While dynamic testing in the field had been criticized as inaccurate compared to static testing performed within a laboratory, the severe conditions it replicated helped to predict how well an envelope would perform over the long term. Voss’s involvement with such notable projects, and the depiction of such at BRI conferences, illustrates how scientific research and testing were considered integral to the design of curtain walls in order to maintain visual control over the product as much as to ensure its performance.

Albert Dietz, who had advised the United Nations Planning Office on the caulking compounds, glazing putties, mastic sealants, and neoprene channels for the Secretariat’s facades, was one of the foremost experts in building with plastics. Dietz had worked for the Office of Scientific Research and Development during the Second World War, after which he established the Plastics Laboratory at MIT, the first such facility to

\textsuperscript{108} Ibid., 6-7.
study the construction potential of plastics. It was through this laboratory that he became involved in the design of the Monsanto House of the Future, built in Disneyland in 1957 to demonstrate the possibility of constructing a nearly all-plastic home from prefabricated parts.\(^{109}\) At the 1957 BRI conference Dietz spoke on the “Importance of Sealants and Adhesives in Building.”\(^{110}\) Noting the shift towards “component construction,” or the aggregation of standardized units to produce nonstandard buildings, Dietz pointed to the increasing reliance upon adhesives and sealants to realize weathertight joints between components, as well as to dampen noise created by vibrating or shifting components.\(^{111}\) Because more buildings were designed to be constructed from components fabricated offsite, there was a growing need for field-applied adhesives and sealants able to absorb dimensional changes and the various thermal behaviors of different materials. The use of expansive panes of glass in buildings being designed for maximum transparency and planar smoothness placed far greater stress on sealants than that which had been applied by smaller windows on glazing putties. A major challenge to specifying sealant materials

\(^{109}\) To promote the use of plastics as construction materials, especially in housing, Monsanto sponsored a major research initiative at MIT’s Department of Architecture, which culminated in the House of the Future. At the 1957 BRI conference Dietz cited the Monsanto House of the Future as an example of the use of synthetic rubber gaskets to join molded reinforced plastic shell sections, with a polysulfide-rubber mastic used as a sealant. Window glass was set in chloroprene-rubber channels and sealed tight with polysulfide-rubber glazing compound. See Albert G. H. Dietz, “Importance of Sealants and Adhesives in Building,” in National Research Council (U.S.), Building Research Institute. Adhesives and sealants in building; a research correlation conference conducted by the Building Research Institute, December 4 and 5, 1957, at the Shoreham Hotel, Washington, D.C. (Washington, 1958), 6.

\(^{110}\) Dietz had helped to specify the flexible mastic sealants used at expansion joints in the marble end walls of the Secretariat to relieve stress from the compressive weight of the structure, wind loads, and variable temperatures.

\(^{111}\) Dietz, “Importance of Sealants and Adhesives in Building,” 3.
was the difficulty of predicting long-term behavior and durability based on the outcomes of short-term tests:

The complexities of weather, involving many subtle interactions of ultraviolet, visible, and infrared radiation with the components of the atmosphere, changing temperature, and moisture in vapor, liquid, and frozen form, make laboratory reproduction, especially in accelerated form, a most difficult problem. Add to this the extreme variability of the weather itself, even in a given locality, and the wide departure in the microclimate of a given building from the mean weather for the locality, and the problem is seen to be formidable.  

The vagaries of weather, understood both as large geographically-derived systems and in terms of the most localized microclimates, had to be accurately modeled in order to design and test curtain wall assemblies for impermeability. The introduction of new sealant and adhesive materials to the building trade entailed new forms of testing to guarantee their performance; mockups and laboratory tests simulated the behavior of material aggregations in the face of manifold atmospheric potentialities. Dietz made clear that when it came to construction research, material properties must be meticulously observed as well as calculated.

As a subject around which a technical research network developed, the curtain wall systems devised during the 1950s established an experimental model situated outside the bounds of a laboratory. While the design of these membranes was based on solar heat gain calculations and controlled testing of material assemblies, dynamic testing

112 Ibid., 8.
on mockups in the field was necessary to analyze conditions indiscernible through predictive models. Because theoretical assumptions regarding curtain wall composition had to be tested under climatically accurate conditions to evaluate their performance on site, the production of “tight” environmental enclosures was itself an experimental enterprise.

“Climate à la Carte”

If the accurate assembly of curtain walls was studied and perfected by a range of technical actors, environmental control systems were the counterpart to exterior envelopes in the formulation of a new model of enclosure. The composition of minute components within the Secretariat’s facade epitomized the model of visible and verifiable precision guiding contemporary practices of materials science, while the regulation of the building’s interior atmosphere reflected an emergent notion of environmental precision.

A September 1949 New York Times article entitled “Climate à la Carte in U.N.’s New Home” described the air-conditioning system being designed for the new UN headquarters in midtown Manhattan, with individual controls to create "climactically perfect" conditions for staff [Fig. 1.35].114 This would be a vast improvement over the perpetually icy conditioned air of the temporary UN headquarters at Lake Success, New York, where New Zealand delegate Sir Carl Berendsen threatened to sport mittens to meetings in defense against the “‘violent Antarctic blizzards’…numbing the hands and

heads of the unhappy diplomats.” Clearly, the article asserted, this inhospitable interior climate presented an obstacle to international cooperation [Figs. 1.36, 1.37]. At the new headquarters, the Secretariat tower would provide office space for 4,000 employees from around the world, with the largest air-conditioning system with individuated controls ever implemented, according to J.A. Cutler, president of Johnson Service Company, Milwaukee-based purveyors of pneumatic temperature control systems, who maintained that office temperatures ought never become a “‘barrier to United Nations harmony,’” ensuring that the manual controls would allow nearly every occupant of the building “to select his own weather indoors.”

The environmental controls strategy for the United Nations Secretariat building consisted of an interior zone serviced by a low-velocity ceiling system, with supply air diffusers and return outlets positioned in the suspended ceiling of perforated acoustical panels, while a 12-foot-wide zone along the east and west window walls was served by high-velocity induction Carrier Weathermaster Conduit units positioned under 6 out of the 7 windows constituting each bay and fed by chilled water drawn from the East River, with hand-operated controls at every other unit [Figs. 1.38, 1.39]. Together with the perimeter air conditioning units and tinted heat-absorbing glass, operable double hung aluminum sash windows and “Flexalum” venetian blinds were intended to provide maximum flexibility for control of the interior climate [Fig. 1.40].

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115 Ibid.
116 Ibid.
117 “U.N. Headquarters, Progress Report,” Progressive Architecture 31 (June 1950), 65. In the summer the interior zone of the building would be maintained at 78 degrees F and 50% relative humidity, and in the winter the base temperature would be kept at 70-72 degrees F, with adjustable humidity levels in order to prevent condensation.
118 Robert Heintges, “The United Nations Secretariat Curtain Wall History, Current
advances in mechanical systems, however, the architects already saw the breathable envelope as an obsolete and unscientific means of environmental control:

Individual control is important in the buildings of the United Nations, the occupants of which have a diversified climatic background and may have varying standards of comfort. For the same reason, it will be desirable to permit individuals to open the windows, although it is expected that they will actually do this only rarely since they can go to a window unit and adjust the equipment to meet the exact conditions desired.\(^{119}\)

A sealed membrane with full air-conditioning was presented as the most precisely adjustable, efficient, and economical means of constituting an interior climate. Despite significant solar heat gain from the glazed east and west facades of the Secretariat, the architects justified the necessity of circulated conditioned air, and downplayed its cost, by highlighting the admission of daylight and provision of views over the city which were made possible by the window walls:

Detailed cost analysis by the engineers indicates that differences in the cost of initial construction and operation of air-conditioning due to different orientations of the main building structures are relatively small, so that other factors will be the determining ones.\(^{120}\)

A section on “The Architectural Organism” in the 1947 design report submitted to the UN General Assembly by the international committee of architects outlined the interaction of building elements, in which air-conditioning functioned as part of a “single coherent organism,” together with structure, lighting, acoustics, communications, and

\(^{119}\) Report to the General Assembly of the United Nations by the Secretary-General on the Permanent Headquarters of the UN (Lake Success, N.Y.: United Nations, July 1947), 32.

\(^{120}\) Ibid. See also Henry S. Churchill, “United Nations Headquarters: A Description and Appraisal,” Architectural Record 111 (July 1952), 109. The Secretariat was apparently given a high-rise form to enhance intercommunications within the building through denser office space. The north-south orientation of the building was determined to cast less shadow over the UN site, though of course this decision entailed much greater costs in heating and air conditioning.
circulation systems [Figs. 1.41, 1.42].

The concept of “man-made weather” functioned as both cultural rhetoric and scientific doctrine as air-conditioning became an ostensibly necessary commodity within both residential and office buildings. By persuading the consuming public that an artificial climate was a requirement, engineers could then present the technical means to achieve such environmental control as a matter of broad concern. But if nature provided the model for interior climates, the norms of man-made weather were entirely technical. The Carrier Engineering Corporation sponsored research programs that established certain dimensions of performance, such as humidity, as key to precisely standardized environmental control, thereby codifying quantitative standards for artificial climatic comfort for the air-conditioning industry, which were then widely marketed. Carrier’s invention of the Conduit Weathermaster System in 1939 extended the benefits of “comfort air conditioning” to skyscrapers by minimizing duct size to reduce loss of profitable ceiling space, and by providing compact, individually operable window units capable of heating and cooling air year round. From the mid-1940s on, data showing

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121 Ibid., 27-39.
122 See Gail Cooper, *Air-Conditioning America: Engineers and the Controlled Environment, 1900–1960* (Baltimore: Johns Hopkins University Press, 1998), 186. Cooper argues that beyond the public relations gambit, the concept of “man-made weather” framed the way in which engineers understood their own work. Laboratory researchers attempted to mimic the effects of breeze or sunlight against human skin through the use of variable fans and ultraviolet lamps.
123 Ibid., 187-188.
124 Margaret Ingels, *Willis Haviland Carrier, Father of Air Conditioning* (Garden City, NY: Country Life Press, 1952), 88-93. This was done by using small quantities of air discharged at high velocity through ejector nozzles, and also establishing induced airflow through a return grille. Primary air supply and secondary induced air would then be heated or cooled by coils in cabinets or wall units below window sills to achieve the appropriate temperature before being returned to the room at a discharge outlet at the window sill. Cabinets could be retrofitted to existing building while wall units could be
increased productivity within air-conditioned environments, combined with the evident real estate advantages of a “deep space” office block form reliant upon artificial lighting and ventilation, were used to validate the nascent typology of sealed glazed towers equipped with mechanical air conditioning systems.125

The capacity to select one’s own weather in a mechanized and precisely regulable interior was interrelated with the technical problem of heat gain through a building’s skin, especially pressing in tall buildings with extensive glazing [Fig. 1.43]. In 1956 the BRI held a conference on “Windows and Glass in the Exterior of Buildings,” in which speakers addressed problems of day-lighting, glass technologies, solar control, and general design issues. Henry Wright, an architect and technical consultant to Building Products Magazine as well as to several manufacturers, spoke on environmental controls systems as they interfaced with new curtain wall techniques, which he presented as primarily an economic problem.126 For glass-skinned tall buildings in Manhattan, Wright stated that the two main factors for calculating heat loads were the skewed street grid, 28 degrees off the true north-south axis, and the impact of what he termed “industrial

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125 Cooper, Air-Conditioning America, 158-162.
atmosphere.” The effect of such in Manhattan was to more evenly distribute heat-gain values and solar load between the four faces of a standard square-plan office tower.[128] [Fig. 1.44] By comparison, the oblong slab form of the Secretariat would have two peak solar loads: one at around 10 am and another at around 5 pm, with a maximum load at 11 am caused by the east window wall. To counter these peaks, and thereby reduce air-conditioning costs, Wright argued that external shading devices and reduced perimeter glazing would be more effective compositions for the enclosure, in effect refuting the value of technical work to perfect smooth, impermeable glass skins, examples of which were presented at the same conference.[130]

To present his argument against the taut glazed envelope of the hovering slab form, Wright showed three heat flow diagrams for windows in an industrial atmosphere. One showed a double plate glass window with a “perfect,” i.e. solid, sunshade, which would reduce heat gain by approximately three quarters compared to an unshaded window [Fig. 1.45]. The second diagram showed a double-glazed window with an exterior face of heat-absorbing glass, which he claimed blocked sight lines and might also reradiate heat to the internal layer of standard glazing. This configuration reduced heat

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[127] Wright, “Exterior Controls,” 116. New York was in fact the site used to develop the figures used to factor in the effect of industrial atmosphere in heat gain calculations.

[128] Ibid. Due to the skewed grid, the heat-gain values for a tall building’s east and west faces would be reduced but those of the north and south faces would rise. In fact, the slanted street grid and "industrial atmosphere" helped to break up solar heat load more evenly between building faces, thus requiring more evenly distributed air conditioning loading, and urban density further reduced solar load.

[129] Ibid. Using a chart illustrating the heat gain on an August day for a square office tower with a 50-percent-glazed total wall surface area, with peak heat gain coming from the south and west façades Wright demonstrated that the heat gain chart would differ for a building with a form and orientation like those of the UN tower. This was indeed what had been measured for the existing building.

[130] Ibid., 116-117. At the same conference Bruce J. Graham of Skidmore, Owings and Merrill gave a talk on glass-skinned office buildings. Ibid., 145-149.
gain by up to two thirds that of an unshaded window [Fig. 1.46]. The final diagram showed a single-pane plate glass window with white interior blinds or shades, the configuration closest to the Secretariat’s envelope. Even when these covered the entire window and were kept completely closed, the heat gain reduction was only 50 percent [Fig. 1.47].

These diagrams and calculations offered a means of communication by which architects, mechanical systems engineers, and manufacturers of curtain wall components and air-conditioning systems could set accurate performance criteria for enclosed environments, but Wright’s presentation also exposed a conflict unique to the construction of such enclosure. Which element of its composition should take precedence, the skin, whose technical resolution served aesthetic ideals, or the air-conditioning system, whose design was typically framed in terms of flexibility and economic efficiency? This was in part a rhetorical issue. How could technical research be used to support the argument for the desired smoothness in glass skins? How could standards of comfort and efficiency be established for a model of enclosure that remained so indeterminate? But the technical debates surrounding the development of building envelopes and correlated systems of environmental regulation were also a question of representation, as scientific research and experimentation were used not only to test various configurations of enclosure, but also to codify an improvisational form of

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131 Ibid., 119-121. While New York City air-conditioning engineers tended to discount the cost impact of external shading, assuming that building occupants would simply close interior blinds to block out sun, Wright argued that his diagrams made clear that exterior controls were the best technique for correcting existing design errors, or to further reduce heat gain once building orientation and surface area of glazing had been sufficiently addressed: “When all other factors have been taken into account, blocking a square foot of sunshine which would otherwise enter the building during the peak air conditioning hour can still save five dollars, whether the glass areas are large or small.”
construction. In turn, the widely disseminated imagery and rhetoric of precisely measured material assemblies and accurately calibrated interior environments at the Secretariat symbolized the UN’s dexterity in containing and modulating a miniature world.  

**Fragmentation and the New World Order**

The progressive technical and aesthetic reverberations of this model of enclosure—from the smallest material detail, to interior atmospheric conditions, to the organization of workspace, to façade composition, to the building’s legibility within both a particular urban and a more generalized global context—illustrate the fragmented and conflicting interpretations of environment, nature, and the organic in the period. The summoning of scientific precision indicated that environment, at least as formulated by the UN, was no longer considered in terms of a finite body of natural resources but rather as something to be constructed and managed to accommodate organizational and economic imperatives.

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133 Michael G. Barbour, “Ecological Fragmentation in the Fifties” in *Uncommon Ground*, ed. William Cronon (New York: W.W. Norton, 1995), 233-234. During the early 1950s ecological thought underwent a shift from a holistic model of predictable interrelated organic communities to a fragmented, individualistic model of nature based on probability. This new reductionist model suggested that the effects of environmental change were contingent upon a number of species-particular factors. Barbour argues that this transition from holism to reductionism is a recurrent theme in the history of science. Holism, which includes animism and vitalism, presumes that the whole is more complex than the sum of its parts. By contrast, reductionism proposes that any object or system may be understood through dissection and study of its constituent parts.
Those who affirmed the Secretariat’s sleek form and flexible environmental controls as providing an ideal framework for assimilation to the American way of life represented a parochial perspective on the obligations of the United Nations within the international sphere. The task of the Headquarters, according to architect Henry S. Churchill, was to "make the process of adjustment to our way as painless as possible. The result, of course, is a forceful expression of Our Way, not theirs." Dominating the UN campus, the Secretariat’s office tower form represented “the clerical worker with his paper-shuffling…the typists, file-clerks, the men and women in the little cubicles,” who ensure that “the wheels go ‘round” not only in organizations like the U.N. but in all businesses. According to Churchill, this bureaucratic model was to become disseminated globally through the form of the Secretariat, in which an international workforce with “a variety of physiological natures” was offered environmental flexibility through individually controlled air-conditioning units, as well as support for “psychological problems of adjustment” to the technological devices within the building. Through aesthetic means, the Secretariat’s technical constitution was to be instilled within its workers, who would become emissaries of a new capitalistic global

135 Ibid., 111. As a quintessentially American form, Churchill saw the office tower of the Secretariat as “an up-ended filing case for human beings, their hopes, their fears and their aspirations for a steady job.” Ibid., 113.
136 Ibid., 114. Churchill conflated the physiological and the psychological in his proposition that the would pay off "in better morale, and probably in fewer respiratory troubles.” Despite this, Churchill queried the choice of large windows for the office floors, a given of the American glass curtain wall typology, suggesting that such expansive glazing was an aesthetic choice, and not strictly necessary for the transmission of light to the interior. At the same time, he praised the use of identical glass on both east and west facades, despite the fact that the tinted heat absorbing glass was superfluous on the east elevation, as this provided a more continuous interior experience, which would be psychologically easier on the inhabitants.
order characterized by efficiency and technical skill, and represented here in the peculiarly American “architectural genius” manifested in office buildings and factories.\textsuperscript{137}

If Churchill embodied popular support for the Secretariat’s glassy technical perfection, Lewis Mumford assumed the role of skeptical adversary.\textsuperscript{138} Criticizing the “arid neutralism” of its gridded glass skin, Mumford disdained the skyscraper typology as an affront to the manifold global cultures supposedly represented by the UN: “a stock emblem of the things they fear and hate--our slick mechanization, our awful power, our patronizing attitude toward lesser breeds who have not acquired the American way of life.”\textsuperscript{139} What the Secretariat’s architects had failed to realize, according to Mumford, was that technical feats could not compensate for diminished symbolic expression, and moreover that the outward display of such feats signaled architecture’s dwindling social capacity. The confusion by which “an office building has been treated as a monument”

\textsuperscript{137} Ibid., 121. Churchill continues: “Symbols, great art, are not created ad hoc; they are inherent in the cultural and emotional heritage, and appear as such, whether we like them or not.”


was predicated upon the abstraction of scientific expertise, a conflation of technique and representation.\textsuperscript{140} In 1952, as the Secretariat building was nearing completion, Mumford argued for a strict division between the two:

On one side there is the engineering side of building: a matter of calculating loads and stresses, of making joints watertight and roofs rainproof, of setting down foundations so solidly that the building that stands on them will not crack or sink. But on the other side there is the whole sphere of expression, the attempt to use the constructional forms in such a way as to convey the meaning of the building to spectator and user, and enable him, with a fuller response on his own side, to participate in its functions…”\textsuperscript{141}

Mumford’s twofold attack on both the symbolism and technical performance of the Secretariat predicted the entanglement of aesthetic and environmental concerns in the proliferation of glass-skinned tall buildings during subsequent years. He cautioned that new engineering techniques might replace architecture, emptying building of symbolic value: “With air conditioning and a host of other mechanical instruments, building might return once more to the environment from which it started--the cave; in which the exterior, if visible at all, would become a blank shell…”\textsuperscript{142}

\textsuperscript{140} Lewis Mumford, “Symbol and Function in Architecture,” in \textit{Art and Technics} (New York: Columbia University Press, 1952), 114. Mumford was invited to speak at Columbia University as a participant in the Bampton Lectures in America series. These lectures were published as \textit{Art and Technics} in 1952. His penultimate lecture on “Symbol and Function in Architecture” addressed the relationship between technical and representational concerns.
\textsuperscript{141} Ibid., 112.
\textsuperscript{142} Lewis Mumford, “Monumentalism, Symbolism, and Style (Part Two),” \textit{Magazine of Art} 142 (Nov. 1949), 258. The ideal of a constant, calibrated environment sought by engineers and many architects seemed to Mumford to be in opposition to our biological need for atmospheric variation. Twenty years later, in 1969, Reyner Banham attempted to chart a history of architecture through environmental controls, in which he acknowledged the relativity of environmental comfort standards, based on factors of age, culture, and physical and social circumstances. Banham suggests that it was this relativity of
glazed towers has to be considered in relation to his unfolding theory of organic functionalism, a reprisal to technical aesthetics. But in his focus on organic integration through symbolic expression Mumford seemed to dismiss the prospect that specific technical solutions, such as keeping the rain out, might also impart aesthetic effects. How did the material and technical problems of environmental enclosure, such as the convergence of components within a curtain wall assembly, or the regulation of interior humidity and temperature levels, or the control of solar heat gain, also operate at the level of expression?

Though Mumford expressed profound disappointment that the Secretariat building had failed to realize his ideal of a new world center, in which a human-oriented community would counteract abstract universal ideals, he remained vague regarding environmental standards that led to the accusation that British troops were torturing Arab detainees in Aden by subjecting them to the full blast of air conditioning, an act he argues might just as well have been borne of cultural ignorance. At the same time, Banham disparaged passive environmental controls strategies such as those seen in so-called tropical architecture built in sites like central Africa as “such a tyranny that the sealed, glass-walled and necessarily air-conditioned office tower begins to look an irresistible alternative…” Reyner Banham, The Architecture of the Well-Tempered Environment (Chicago: University of Chicago Press, 1969), 300-310.

The concept of wholeness was key to the organic functionalism that Mumford prescribed, in which expression is a function of architecture, and the subjective wellbeing of inhabitants is taken into account. For him Frank Lloyd Wright’s work exemplified this design method, whereas the Secretariat building was an object lesson on the difficulty of unifying function and symbol. He described the building as an empty shell, devoid of human values: "That great oblong prism of steel and aluminum and glass, less a building than a gigantic mirror in which the urban landscape of Manhattan is reflected, is in one sense one of the most perfect achievements of modern technics: as fragile as a spider web, as crystalline as a sheet of ice, as geometrical as a beehive." Mumford, “Symbol and Function in Architecture,” 126-128. See Leo Marx, “Lewis Mumford: Prophet of Organicism,” Working Paper Number 2. Program in Science, Technology, and Society, MIT, accessed Jan. 5, 2012, http://web.mit.edu/sts/pubs/pdfs/MIT_STS_WorkingPaper_2_Marx.pdf.
distinctions between the international, the universal, and the global. Mumford classified the Secretariat—superficially perfect and easily replicated—as at least nominally in the “international style,” a mode which he abhorred for the perversity of prescribing the same glass facades, “that visual tag of modernism,” for sites with such divergent climates as Russia and North Africa [Fig. 1.48]. This, Mumford suggested, was not internationalist at all, but was in fact “the covert imperialism of the great world megalopolises.” Mumford’s bewilderment was symptomatic of a period that witnessed the beginning of a transition from an international to a global order, towards an increasingly totalizing economic system of presumptive shared interest. In architecture, this implied new conglomerate forms of practice—much like the design committee for the UN headquarters—engaged in projects distributed across the globe, using working methods, materials, and forms of enclosure that were in many ways predicted by the

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144 In his 1946 address to the Royal Institute of British Architects on “A World Centre for the United Nations, Mumford had outlined a proposal for a world city built around the human scale, which was roughly modeled on the garden city principal. It was important to Mumford that this world city should counteract the destructive tendencies of modern technics (the most brutal example of which was the atomic bomb), by providing a more human scale that would somehow impart the idea of a more cooperative world order.  
145 Lewis Mumford, “The Sky Line: Magic with Mirrors,” 37-44. Mumford claimed the tower presented a two-dimensional image of perfection, “impeccable but irrelevant,” and a superficial romanticizing of engineering and scientific technique with flimsy symbolic consequence: “Should one look behind this magician’s mirror, one should not be surprised to find, if not a complete void, something less than good working quarters for a great world organization.”  
146 Lewis Mumford, “Monumentalism, Symbolism, and Style (Part One),” Magazine of Art 142 (Oct. 1949), 206, 227. Mumford argued for a shift from that totalizing machine-driven ideology towards a more subjective perspective. If the dictatorial aesthetics and environments of the International Style were generic, Mumford called for an architecture animated by personal choice. Ibid., 259. This was a continuation of the 19th century duality between organism and machine, influenced by his reading of Alfred Whitehead, whose 1925 critique of scientific materialism presented the organic worldview as a protest against the exclusion of value from the essence of matter of fact.” Alfred North Whitehead, Science and the Modern World: Lowell Lectures, 1925 (New York: Macmillan, 1925), 133.
design of the Secretariat.

The UN itself was, as Mark Mazower has described it, “an international organization with global aspirations,” which employed a deliberate ambiguity to facilitate evolving policies and positions in relation to a shifting world order. If the internationalist schema had been characterized by imperialism, universalism, and cohesive stylistic elements, the Secretariat’s technical systematization of environmental enclosure presented an early example of what could be called the architecture of worldwide economic expansion, marked by a diffuse set of generic techniques in place of any particular stylistic model. Collaborative design processes by bodies of experts underlay this globally dispersed architecture, and the discourse surrounding the construction and management of environment was one specific instance that evinced this general dissemination of technique from an American locus outward to the developing world. This was a period marked by the rise of global developmentalism through industrial growth, which helped to concretize a means of structuring societies and nations around purely pecuniary aims, thereby strengthening capitalism as a world system. Various United Nations programs worked to foster this developmentalism in the face of challenges to American hegemony. Amid pervasive uncertainty over the future of international relations, the enclosure fabricated at the UN Secretariat—reliant upon overt and covert exactitude to coalesce apparently anonymous and fragmented components—

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147 Mazower, No Enchanted Palace, 194. “Tension and ambiguity were thus hardwired into the UN from the start. It promised more about rights than the League, but did less about them. It gave more power to the permanent members of the Security Council but opened its doors to a much larger cohort of new, independent states than the League had done. The result was both weakness and flexibility, allowing a new world body to shed one skin after another in response to the changing climate of international affairs.”
manifested precision as a critical epistemic virtue of global postwar corporate architecture and the institutions it serviced.
Chapter 2:  
An Environment for Industry: The Cummins Engine Company and the Commercial-Philanthropic Sphere, 1963-1975

In the period spanning from 1953, the year the United Nations Secretariat building was completed, to 1973, worldwide manufacturing output more than tripled. Propelled by the recovery of economies that had been crippled by war, the repurposing of technological developments from the war effort for peacetime uses, a generalized shift from agriculture to industry underwritten by global developmentalism, and the implementation of planned economies, especially in the Third World, to capitalize upon available natural resources, this unprecedented increase in industrial production was matched by an exponential expansion of international trade in manufactured goods.\(^{148}\) During this “Golden Age of Capitalism” in the 1950s and 1960s, the United States and Europe both operated on a Keynesian model, with states regulating both economic growth and social programs, but towards the end of the 1960s a swelling of corporate capital disrupted this government-centered collective order. There was a shift away from the jurisdiction of shared responsibility seen in the immediate postwar period towards a system that privileged individual entrepreneurialism and the eventual dismantling of economic regulatory measures and social services, in which state sovereignty would give way to the seemingly boundless scope of multinational corporations.

In many respects the worldwide business operations of the Cummins Engine Company signaled this transformation. One of the largest American industrial enterprises in the period, during the 1960s and 1970s this diesel engine manufacturer involved itself

in a contentious domestic discourse on civil rights, labor standards, urban blight, and environmental protection, all the while intensifying its efforts towards global expansion. Cummins’s approach to environmental management as both an internal concern directed towards maximizing labor efficiency, and an exemplification of the corporation’s outwardly progressive stance, demonstrated the company’s entanglement with the era’s prevalent social, political, and economic debates.

In November of 1973, Cummins Engine Company chairman J. Irwin Miller wrote to Kevin Roche regarding the exterior glazing that his firm, Kevin Roche John Dinkeloo and Associates (KRJDA), were in the process of designing for Cummins’s new headquarters building in Columbus, Indiana. The architects had also designed two glass factories for the company. Miller attached a clipping of a New York Times editorial entitled “Energy Revolution,” which critiqued the overconsumption of energy in “completely artificial, sealed, climate-controlled and standardized” American buildings. The article denigrated the whole enterprise of environmental control systems, linked to sealed glass buildings, as the source of a nation-wide energy crisis:

…The techniques that render the bulk building with huge floor areas habitable have made real estate big business through a profligate use of energy almost beyond comprehension. There has been joy and prosperity among the purveyors of ducts, pipes and plenums and luminous ceilings by the acre.

In pursuit of this dollar-value technology, today’s buildings are blatantly unresponsive to human or environmental factors. They are routinely over equipped mechanically to handle heating and cooling loads that are far too high, and they are universally overlit. There are no seasons. Windows

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never open. And the handsome conceits of the modern architect compound the damage. The glass box stands in pristine esthetic splendor and relentless sun. There has even been an odd architectural pride in flouting the environment, a look-what-we-can-do race to the energy crisis.\textsuperscript{150}

Miller asked how this critique of energy consumption in glass buildings should impact the design of Cummins’s own extensively glazed facilities, presumably fearing that an image of excessive consumption would tarnish the company, especially at a time when the diesel engines it manufactured were subject to scrutiny due to more stringent emissions standards. Roche countered that while ordinary New York office towers might waste significant quantities of energy, they were even more disgraceful in their disregard of the human condition, which was a result of poor design rather than any choice in materials:

\begin{quote}
It is too easy for the non-technically informed to equate glass with energy loss. Glass is a splendid material, possessing great qualities of permanence and easy maintenance. Unlike aluminum, it does not require enormous amounts of energy for its production. Glass used properly can help both the current drive towards reduced energy consumption and, what should have been a constant objective in everyone’s mind, the creation of decent and stimulating living and working environments.\textsuperscript{151}
\end{quote}

To Roche’s mind, disparaging glass buildings showed an ignorance regarding the technical dimensions of material and energy questions as well as a philistine’s indifference towards the aesthetic experience of work. KRJDA, whose technical research program entailed the adaptation of materials developed for parallel industries towards prototypical architectural applications, had developed a special expertise in techniques of

\begin{footnotesize}
\textsuperscript{150} Ibíd.
\end{footnotesize}
glazed enclosure. The industrial buildings that the firm completed for the Cummins Engine Company during the 1960s and 1970s reflected the architects’ and client’s professed mission to improve the work environment at all scales. These projects characterized KRJDA’s paradigmatic approach to the design of corporate space, and distilled the era’s unique tension between social and environmental progressivism on one hand, and global corporate expansion on the other.

**Cummins Darlington: an Instrument of International Expansion**

From its inception the Kevin Roche John Dinkeloo and Associates (KRJDA) practice developed a particular working method that relied heavily upon both technical research and tight a management process in the name of economic efficiency. This model of practice not only reflected the contemporary business climate, with an increasing number of large corporate clients from the late 1950s on, but it also served the expanding influence, culture, and economic power of such corporations by creating the spaces for their growth [Fig. 2.1].

In November 1962 John Dinkeloo addressed Yale University architecture students on the business of architecture. A central preoccupation of his talk was how to maintain the integrity of the architect’s role in dealing with increasingly large and domineering corporate clients, and he offered technical and material research as a primary endeavor in which the knowledge and skill of the architect might be applied towards the production of “complete architectural projects, which are not just

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152 Dinkeloo was then partner in the firm of Eero Saarinen Associates, soon to be renamed Kevin Roche John Dinkeloo and Associates (KRJDA), who were at the time completing the projects begun before Saarinen’s untimely death in September 1961.
clichés…” While material manufacturers might be engaged in product development, devising glass with decorative decals and other such trivialities, Dinkeloo asserted that his firm’s in-house technical research program had the capacity to more directly serve the material, spatial, and environmental objectives of their practice. He cited their work on the structural neoprene gasket, first used on the 1955 General Motors (GM) Technical Center, designed by Saarinen with Detroit firm Smith, Hynchman & Grylls, as the genesis of their research method, which was typically motivated by a desire to repurpose a material or assembly borrowed from other industries in an unprecedented way [Fig. 2.2]. This research method demanded perseverance from both architect and client, as a certain amount of trial and error was required, as was the case when the Saarinen office worked to adapt GM gaskets for the Technical Center buildings:

> With these manufacturing people we sat down and worked, maybe, it varies, we worked for probably six months, on developing what we felt would be an architectural product, based on what they had done originally and bring it up to a satisfactory project. Now, in all of these things as in all research…they never quite work the first time. And so you’re going back and forth and making these modifications.155

Dinkeloo was enamored of the tinkering aspect of this research, admitting to setting up his own material weathering test lab at home in his kitchen using the oven, freezer, and sink on 8-hour cycles, much to his wife’s consternation. But he was also...

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153 John Dinkeloo Talk, Yale University School of Architecture. Nov. 1, 1962. Part I. Yale University Archives… [c. 35:20] Dinkeloo later explains: “We would like to do a certain type of architecture. We can only do it if certain things can be accomplished in the material field. And as I say it’s useless to take these problems to a manufacturer.” [c. 44:21]

154 “Most of the time what happens is, as you develop you say well now so in the aviation business is doing this, Now this doesn’t fit our particular item we want to do exactly, but maybe by taking this process, or this particular item, and modifying it, we can come up to the results we want.” Ibid. [c. 47:07]

155 Ibid. [c. 47:08]
deeply cognizant of the conviction required from the client to achieve such material innovations, in terms of moral support even more than financial outlay. While the development of these technical, material aspects of building required scientific research, Dinkeloo viewed them as linked to the broad conceptual basis of a project, rather than as isolated, fragmented details. Technical questions had to be resolved and managed within the context of the architect’s broader theoretical ambitions for a work. At a subsequent talk at Yale in October 1963, Dinkeloo explained that the rise in corporate clients, who demanded buildings that were both outwardly impressive and economically efficient, made the balance between the technical and the conceptual more difficult to achieve:

The people who are building buildings today, and have money to build buildings today, are the people who are usually business clients...And when you go into a big corporation you hit a man who might be very very enthusiastic about good architecture, or you wouldn’t be there, but still he has a board of directors behind him and he has a group of stockholders behind him and he has to justify everything he does to these people so he, besides wanting a [sic] outstanding building also wants one that technologically is perfect.

Because architectural production, unlike automobile production, involves the serial creation of prototypes, technological perfection in building is extremely difficult to attain, Dinkeloo cautioned, but the changing climate of architect-client relations following corporate growth in the 1950s meant that professionalism for architects had

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156 “And unless you have a client who is, well let’s say willing to go along with you for a little bit on this thing, and willing also to, you go to them and say well this has never been used before as a building product, and is willing to say ok go ahead, while you run into a lot of problems...so you’re heapin problems on yourself,...which you won’t get paid for or thanked for, but I think it’s the only way that products are ever going to be developed, as such.” Ibid.
157 John Dinkeloo Talk, Yale University School of Architecture. Oct. 1963. Part II. Yale University Archives... [c. 10:39]
come to imply greater technical expertise than ever before. At the same time, architects were tasked with developing fluency in the lexicon of commerce, in order to persuade corporate clients that the buildings and spaces they designed would support profitable enterprise: “If you can’t talk their business knowledgeably, why you certainly can’t do business with them, because then you’re doing business on an aesthetic basis.” In his talks to Yale students Dinkeloo portrayed the economic system of architecture in a way that schools typically failed to address in design studios and theory seminars. His emphasis on the importance of the relationship between technical dexterity and commercial acumen predicted the operating principles that the KRJDA practice was to develop in the ensuing decade.

The “managerial and technical proficiency” of the practice, as one article put it, extended throughout the research, design, and construction phases of a project. At each stage Dinkeloo sought the most efficient and economical means of production, from developing experimental new products with manufacturers, to watching the materials market using the Wall Street Journal or advice from acquaintances in the construction supply business to determine the best time to issue bids and to buy materials. This kind of

158 “By professional I am thinking in terms of the let’s say technical aspects of architecture…This is becoming a much and much harder thing because we are reaching out much further every time to do outstanding projects which brings us out into a far-stretching technological situation. The owners of the present day buildings most times in this day and age are big business, people who are pretty savvy at least in business, and even on any project there is getting more a tendency to, every time you make a technical mistake, for the owner to come back and say ‘Well gee whiz you made a mistake and this is a twenty thousand dollar mistake to me and I would like to take this out of your fee.’” Ibid. [c.6min53sec]:


value engineering was considered integral to the architect’s responsibilities to ever more demanding corporate clients, who expected nothing less than technical perfection and the utmost in spatial and environmental efficiency with minimal financial outlay.

The structural gaskets that Dinkeloo had developed for the GM Technical Center while working within the Saarinen office, were components of a project that, situated on the outskirts of Detroit, in Warren, Michigan, formed part of a broader move to establish centers of research and production outside the bounds of the city. Following the rapid growth of the auto industry in America’s Midwest from the early 1950s on, its urban centers could no longer accommodate the large plants necessary for production. The expansive green fields and fresh air were seen as an antidote to urban congestion that could accommodate new facilities necessary for profitable industrial development.

While the American auto industry continued to expand, the north of England saw a postwar decline in industry, and it was within that context that Kevin Roche John Dinkeloo and Associates (KRJDA) carried out their first project as an autonomous practice, no longer operating under the Saarinen name [Fig. 2.3]. The city of Darlington, whose Victorian train station by William Bell was the terminus of the Stockton and Darlington Railway, the world’s first commercial steam railway, was a center of 19th century industrial manufacturing.\(^{161}\) Electricity was first generated in Darlington at the turn of the 20th century, and it was the site of the world’s first cinema, but in the years after the Second World War and closure of the railway engineering works it experienced significant economic depression. A UK government program was implemented to

\(^{161}\) The Stockton and Darlington Railway also served the coal shipping industry in the nearby port at Middlesbrough. Darlington was a center for bridge building, exporting bridges worldwide, and for the manufacture and repair of railway rolling stock.
promote local industrial development by providing incentives for manufacturers to establish operations in the area, and in 1963 the Cummins Engine Company of Columbus, Indiana purchased a 50-acre site for two buildings: a plant to manufacture a new diesel engine for subsidiary company Chrysler-Cummins, and a component plant for Cummins Engine proper. This was to be the first purpose-built overseas facility for Cummins, which was in the early stages of a major international expansion program.¹⁶²

Established in 1919 to manufacture diesel engines, the Cummins Engine Company experienced rapid growth in the postwar years; by the mid-1960s it was one of the largest corporations in the United States, supplying the majority of diesel engines used in American trucks, and a leading international diesel engine manufacturer. Its chief rivals were General Motors’ diesel subsidiary, Detroit Diesel, Mack, and Caterpillar. While Caterpillar sold the highest volume of diesel engines in the United States in the years following WWII, due to sales of its own tractors, Cummins assumes a 55 percent of the truck engine market, compared to 37 percent for Mack.¹⁶³

Cummins chairman J. Irwin Miller had imagined a multinational presence for the company during the war, writing to a representative of the New York-based Chemical Bank: “‘We are also much interested in making a connection somewhere in the British empire, and quite possibly in England itself…’”¹⁶⁴ While the US government promoted

¹⁶² An article on factory design in the *Official Architecture and Planning* journal remarked on the irony that Cummins, a diesel engine manufacturer, should be the source for new jobs in Darlington, which suffered major unemployment when the rise in truck transport led to the closure of its rail engineering works. See “Factory Design International,” *Official Architecture and Planning* 32 (July 1969), 809.
¹⁶⁴ Ibid., 183.
overseas trade in the years following the war—through the Marshall Plan, the General Agreement on Trade and Tariffs, the Economic Cooperation Act to promote investment in Western Europe, and President Truman’s Act for International Development—Cummins took a special interest in establishing operations in Britain after the United Kingdom limited imports in 1950 in order to redress the imbalance between US and UK production. At the time, British trade regulations applied to all countries that used pounds sterling, so a UK-issued restriction of imports affected a number of economies worldwide, creating difficulties for Cummins in the distribution of its engines across the globe as it was frozen out of a number of markets, resulting in significantly reduced sales.\textsuperscript{165}

In 1957 Cummins established its first foreign manufacturing operation in Shotts, Scotland, and Cummins Diesel International was founded in 1958. The company subsequently formed regional offices and distributor operations in over 120 countries, and built manufacturing operations in Australia, Germany, Great Britain, India, Japan, and Mexico [Fig. 2.4]. Cummins grew from net sales of $27 million in 1947 to $147 million in 1959 and $331 million by 1966.\textsuperscript{166} Cummins engines were offered in vehicles by International Harvester, Chrysler, Ford, Euclid, General Electric, Mack Truck Company, White Motor Company, Lorain, Richard Frères-Continental, Berliet, Trailers de Monterrey, Kenworth, Ingersoll Rand, and Sicard, and the company aimed to make its diesel engines the most widely used product in the markets for motor trucks, construction

\textsuperscript{165} Ibid., 185.
\textsuperscript{166} Ibid., 176. See also Cummins Annual Report (1966), 2.
equipment, and agricultural and government engines. In Europe, Cummins engines were becoming known for being “‘thirsty but powerful.’” In competition with its rival Caterpillar, Cummins sought a majority of the global market in engines to power the hardware of developmentalism.

The 158,000-square-foot factory at Darlington was planned as an advanced engineering complex to accommodate four major functions: diesel engine component production, pilot installation, reconditioning of engines and their sub-assemblies, and service training. [Darlington’s industrial past was an ostensible lure for Cummins, and its proximity to road, rail, and sea transport networks made it an ideal center for Cummins’s European distribution hub, which would send engine components throughout the world. The Darlington plant was also seen to aid the American economy; it was financed with a $2 million foreign loan to enhance the United States’ balance of international payments.

The Darlington operation functioned as part of the company’s simultaneous international and technical expansion programs. Between 1964 and 1966 Cummins hired over 100 scientists, engineers, and technicians to its Research and Engineering division.

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To reinforce its global manufacturing and distribution network, Cummins established a European Technical Center in Essen, Germany in 1966, and completed a new Research and Engineering Center in Columbus in 1967. The company’s technical planning group worked to analyze new technologies and competitive products, while the product development staff aimed to minimize the financial risk associated with new product development. For the diesel engine company, technical developments such as the 140-200 horsepower V-engine and the small V-engine were indispensable for profitable growth, while robust international manufacturing and distribution bases helped Cummins to capitalize on new product developments [Fig. 2.5-2.7].

Cummins chairman J. Irwin Miller had employed Eero Saarinen to design the Irwin Union Bank as well as his private residence, both in Columbus. Kevin Roche and John Dinkeloo were familiar with the company’s managers, and their experience working on projects like the GM Technical Center made them an obvious choice to design the component plant for Cummins [Fig. 2.8].

The glass factory that KRJDA developed for Cummins at Darlington was, as Roche described it, a “‘big shed…very, very direct stuff.’” The structure of exposed unpainted Cor-Ten steel T- and H-sections formed a grid of 30-foot by 60-foot bays, and

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172 The Irwin-Sweeney-Miller family had commissioned Eliel Saarinen to design the First Christian Church in Columbus in 1942.
173 The London-based firm James Cubitt & Partners were responsible for the design of the adjacent Chrysler-Cummins building. The James Cubitt Architects Nigeria office had been established in Lagos in 1956 following a number of projects in Ghana undertaken by the Cubitt office, which was active in West Africa before and after the decolonization processes. See Mark Crinson, Modern Architecture and the End of Empire (Burlington, VT: Ashgate, 2003), 137-145.
was the first use of high-strength, corrosion-resistant oxidizing steel in England [Fig. 2.9]. Cor-Ten steel had first been used on Saarinen’s building for the John Deere company headquarters in Moline, Illinois, on which Roche and Dinkeloo collaborated, and which was completed two years prior to Cummins Darlington in 1964 [Fig. 2.10-2.11]. All mullions and muntins were formed of the same steelwork, and these were filled in with grey-tinted 7/32” Pilkington Brothers sheet glass, held to the steel framework with the same black structural Neoprene synthetic rubber gaskets that had been developed for Saarinen’s 1955 GM Technical Center, on which Rohe and Dinkeloo had also worked [Fig. 2.12-2.13].

This gasket detail was initially appropriated from automobile production to be used in a kind of synecdochical capacity for a building dedicated to automobile research for GM, and then for Cummins the detail was used to define a production and training facility dedicated to engines powering large-scale automobiles worldwide. The exposed gaskets were to offer superior resistance to sunlight, air, and damp, with a hardness rating of 70-80 Durometer, ensuring that the curtain wall would remain weather-tight for at least two years following the building’s completion. The Neoprene gaskets were selected over alternative schemes employing a channel-shaped

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175 The Neoprene gaskets were welded into a ladder-frame shape off-site, and then positioned next to the steel frame on-site, where they were “unzipped” using a special tool to peel out a V-shaped section. The glass was then inserted before the Neoprene gaskets were zipped up again. See John Winter. “Steel Appeal,” *Architects’ Journal* 195, 12 (Mar. 25, 1992), 45. For more on the GM Technical Center’s detailing see Reinhold Martin, *The Organizational Complex: Architecture, Media and Corporate Space* (Cambridge, MA: The MIT Press, 2003), 148.

glazing bead with Thiokol caulking, and were unprecedented in British building.\textsuperscript{177} The combination of the Cor-Ten steel framework with Neoprene structural gaskets was entirely prototypical, a composite of Roche and Dinkeloo’s previous technical experiments [Fig. 2.14-2.19].

At Darlington, KRJDA elevated the shed typology to a crystalline box through the use of extensive transparency and pristine details, bringing to fruition on the fields of northeast England the “technical perfection” that Dinkeloo had claimed was the architectural objective of major American corporations. The Darlington component factory’s primary function was the production of a range of precision engine components—including Cummins’ proprietary fuel injection system, air compressors, and torsional vibration dampers--, work which required an unusual degree of accuracy, costly machinery, and skilled personnel.\textsuperscript{178} Cummins contended that superior standards of production could only be achieved when quality control standards applied to manufacturing facilities and finished products alike.\textsuperscript{179} This was a notion of design excellence that extended to all scales of the business operation: from company graphics by Paul Rand, to workspaces, to the engines themselves.\textsuperscript{180} Industrial designer and future

\textsuperscript{177} Ibid.
\textsuperscript{179} Cummins claimed that “‘quality control cannot be wholly successful in its aims so long as it is confined to the product. To achieve its ultimate object it must extend to the plant as a whole.’” See “Factory Design International,” \textit{Official Architecture and Planning} 32 (July 1969), 815.
\textsuperscript{180} In 1962 J. Irwin Miller approached Paul Rand to do graphics for Cummins, and he went on to design the company logo and its annual reports, as well as graphic design standards for all Cummins’s print material. Rand’s graphic design experience at the time
Museum of Modern Art curator Emilio Ambasz was appointed as Cummins’ Chief Design Consultant, a role he described as “to provide a coherent language so that all the shapes look as if they come from the same purposeful intelligence.” Cummins directors believed superlative design across all business activities indicated a superior product, and was part of the most cunning business model. In other words, in order to maintain the technical advantage and precise skill that made Cummins engines leaders in the global marketplace, the company required accurately composed facilities and products that represented the precise tooling that the company was known for.

The utility of technical perfection in terms of industrial production and commercial growth was variously understood. Kevin Roche presented the techniques of construction and enclosure at Darlington in neutral terms, claiming that the project was intended to export “the best American tradition” of technological skill, …” through its precision engineering. Others placed more emphasis on the commercial aspect of the factory, describing it as a costly “prestige building,” whose primary purpose was to advertise the technical expertise of its occupants. While some questioned the economy of the building, “too perfect and expensive to serve as an example relevant to other industrialists’ building needs, except in demonstrating the ultimate in aesthetic standards,” Cummins proclaimed its economic efficiency, with a construction

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183 “Factory Design International,” Official Architecture and Planning 32 (July 1969), 815. “Perfection, however, costs money—a great deal in this case, and it must be questioned whether or not this is too beautiful an enclosure for production processes.”
cost of 11.83 U.S. dollars (5 pounds 15 shillings per square foot in UK currency), excluding site and manufacturing equipment, apparently comparable to prefabricated buildings at the time. The construction process took a mere 14 months.\textsuperscript{184} The Cummins Annual Report for 1966, the year the Darlington building was completed, reported that not only did 1965 see the highest sales and earnings in the company’s history and the fifth consecutive year of record gains, but that trade of Cummins products within international markets was at an all-time high, with high horsepower diesel engines being manufactured in the United Kingdom, Germany, India, Japan, Australia and Mexico.\textsuperscript{185}

**An Exported Prototype**

For Cummins, the building’s outward technical perfection served to enhance business operations not only by projecting an image of expertise but also by creating a spare, precise enclosure that mirrored the kind of work being performed within [Fig. 2.20]. The company asserted that despite Darlington’s distance from the Columbus headquarters, and Britain’s unique building codes and construction requirements, the same design objectives applied to international projects as at home: “to provide good architecture, not only aesthetically but a design that is functionally sound at a cost with which we can

\[\text{Here the components plant was compared to blue brindle brick of the Cummins-Chrylser plant, which was presented as an example of a more economically feasible architectural approach.}\]

\textsuperscript{184} See “Dark Steel Pavilion Designed for Export,” *Architectural Forum* 125, 3 (Oct. 1966), 86. See also “An Export of Taste,” *Fortune* 75, 2 (Feb. 1967), 166: “The plant contains no frills—as its construction cost of only $11.83 per square foot would indicate.” See also “Made in Mid-Atlantic,” *Architectural Review* 142 (July 1967), 12: “The building is relatively inexpensive at £5 15s per sq. ft. and construction time had to be fast, but the client was prepared to jeopardize the starting date of the production in order to achieve the ultimate environment he wanted.”

\textsuperscript{185} *Cummins Annual Report* (1966); 3, 14.
live.”¹⁸⁶ As if to reinforce the idea that the Darlington plant was an economical production facility, Cummins professed to concern itself largely with the practical aspects of the project, leaving the aesthetic matters to the architects. Guy Martin, Project Manager for the British buildings, acted as the ‘corporate client,’ and represented Cummins’s interests by coordinating the transmittal of data between the architects, the city of Darlington, the Cummins Special Projects Group, and the Cummins headquarters in Columbus.¹⁸⁷ The company was cunning in its casting of precise architectural technique as embodying at once cutting-edge manufacturing methods and cost-effective facilities. This was the architectural manifestation of Cummins’s corporate strategy: to maintain profitable, spare business operations while continuing to produce a superior industrial product.

Much was made of the notion of exporting technical knowledge, and of the difference between the American and British construction industries. The Darlington project was published in a number of journal articles with such titles as: “Dark Steel Pavilion Designed for Export,” “An Export of Taste,” and “Factory Design International.”¹⁸⁸ Not only were the Neoprene gaskets and Cor-Ten steel of the exterior and interior walls unprecedented in British building, but the grey sheet glass by Pilkington Brothers, produced in St. Helen’s outside Liverpool, was specified for export.


¹⁸⁷ Ibid.

only, so it had to be shipped out to Belgium and imported back to England for the Cummins project [Fig. 2.21]. Moreover, when the architects rejected three-fourths of the British-made neoprene gaskets as too imprecise, it was decided to import all gaskets for internal partitions from the United States. In terms of both material components and techniques of assembly, the building was by and large an imported product. Cor-Ten steel, adopted from highway construction, and Neoprene, adopted from automobile assemblies, were incorporated into details exported from the flat Midwestern landscape of suburban Detroit and rural Illinois to the hills of Northumberland, from the context of a flourishing American automobile industry to the blighted postindustrial terrain of northern England.

A July 1967 article in the *Architectural Review* entitled “Made in Mid-Atlantic,” presented four British factory buildings, two of which were designed by American architects for American companies, and two of which were designed by American-trained British architects. Disparaging typical British-designed industrial facilities as oversized potting sheds in the peasant-craftsman mode, the article praised the American factories’ linear organization of machines and laborers in order to support mass production and “express the corporate identity of social behaviour in each particular firm…” The typology of the American factory, the article asserted, was unique as a simple container of flexible spaces, usually within an exposed steel frame, with offices and zones for

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190 “Made in Mid-Atlantic,” 12-25. The projects included the Cummins factory at Darlington by KRJDA; the Reliance Controls Electronics Factory at Swindon, England by Team 4; the Engineering Factory for Connecticut-based Torrington Manufacturing Company (manufacturers of air-moving equipment and machines to process wire and strip) at Swindon, England by Marcel Breuer and Robert F. Gatje; and a factory for Commercial Plastics Ltd. At Cramlington, England, by Chapman, Taylor, and Partners.
191 “Made in Mid-Atlantic,” 12.
production easily interchangeable, and “no class distinction between manual and white-collar…”\textsuperscript{192}

Designed by Kevin Roche, an Irishman trained in London and the United States who went into practice with an American partner, the article described the Cummins Darlington factory as “perhaps the most professionally conceived building put up in Britain since the war,” for its presentation of a wholly new model of industrial production and workspace in its accommodation of the Cummins enterprise, as well as the client’s support of the design and construction processes. All workers—managerial, clerical, and technical—accessed the factory through the same entrance [Fig. 2.22]. Within the building, factory and office areas were placed in indistinguishable open spaces, while a brick core housed services and training facilities. All machines in the machine shop were painted a glossy white to proclaim their cleanliness; these were objects to behold and revere [Fig. 2.23]. Interior partitions, identical in detail to the external walls, divided workspaces while maintaining complete visual interconnectedness between directors, typists, and factory workers [Fig. 2.24-2.25].

The elevation of industrial machinery, and the equalization of the workforce, ran counter to British tendencies in manufacturing operations. The fact that all offices were equipped with the same chair, desk, and basic grey sisal carpet, regardless of rank, was a novelty for English society: “It is remarkable that an American capitalist can insist on real equality where a Socialist civil servant might still retain the status symbols of differently sized chairs, desks and carpets.”\textsuperscript{193} This was a democratic ideal as enacted by commercial enterprise, a peculiarly American philosophy which considered the treatment

\textsuperscript{192} Ibid.
\textsuperscript{193} Ibid.
of the company worker as integral to profitable activity, and the factory environment as key to its achievement.

In 1964 John Dinkeloo wrote to James Cubitt & Partners, architects working on the neighboring plant for the Chrysler-Cummins partnership, in an effort to convince them to treat the external windows of their brick building in a manner similar to KRJDA’s glass shed:

“I hesitate to bring up the American way of doing things because this does not necessarily mean that it is right. However, I believe the one unity we have achieved in our modern office building is the fact that all windows are treated the same, and that if an executive has various things due to his status they are achieved by carpets, better desks and office furniture or even two pens, and not by curtains or drapes at the windows. I hope we can sell Chrysler-Cummins on this basic philosophy.”

Here Dinkeloo argued that it was not similar interior furnishings that materialized the American commercial democratic ideal, but the treatment of the exterior envelopes. The KRJDA practice’s concentration on the technical aspects of glazing was part of a broader project to increase transparency, visibility, and the accommodation of views in an effort to exalt the individual worker. In a *Fortune* magazine on “An Export of Taste” at the Cummins Darlington facility, Kevin Roche described the building’s expansive glass facades, more commonly associated with office buildings than factories, as part of a program to dignify the experience of the factory worker: “‘If you get back into the depths of a big plant and try to look out of a typical small window…all you will see is a

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rectangle of glare. We wanted to give employees true visual relief. In this plant they can look out and see something.”195

The Cummins building at Darlington was frequently published alongside Team 4’s Reliance Controls electronics factory in Swindon, England, but it presented a very different model of industrial workspace [Fig. 2.26]. Like the Cummins building, completed in the same year, Reliance Controls was a large, flexible, open shed designed to unite managerial with assembly staff in an uninterrupted and undifferentiated interior [Fig. 2.27-2.28].196 The building was lauded for its precise, delicate detailing—a harbinger of what came to be known popularly as high tech architecture—but it was windowless on three sides. The technical perfection of its cross-braced corrugated steel exterior walls had little to do with any individual’s experience of the factory interior [Fig. 2.29-2.30].

Visibility and transparency, both within the factory complex and to the surrounding rural landscape, served Cummins’s corporate mission to address the conditions of the laborer as well as the burgeoning technical-social project of the Roche and Dinkeloo practice. In contrast to the ultimate economic efficiency of the anti-humanistic “windowless air-conditioned modular sealed box,”197 as seen in the Reliance

195 “An Export of Taste,” 166.
197 See “The Anatomy of the Factory,” 525. ““Jacques Barzun doubts C.P. Snow’s ‘two cultures’ and maintains we live in a scientific culture where everything is analysed and measured. If it can’t be measured, it is ignored…All the measurements of flexibility and adaptability, initial cost and cost in use lead, in factory design, to the windowless box. They are built up from the parameters we can isolate, measure and cost. The parameters of human reaction are infinite in number, highly variable and highly subjective and, because of this, very difficult to identify and quantify.”
Controls building, Darlington offered a transparent enclosure that represented technical perfection and industrial superiority while instantiating a corporate ethos of elevating the laborer for commercial benefit. The Cor-Ten steel-framed glass surface was purportedly integral to a business strategy which proposed more commodious spaces for industry, in place of basic containers for men and machinery, in order to enhance the work experience and thereby the quality of production, as well as profitability. At the same time, this transparent factory on a rural site conspicuously presented the kind of sleek, precisely manufactured and tooled material assembly more commonly associated with office buildings and research facilities than with industrial production. Together with Dinkeloo, Roche, who had worked as a ‘backroom boy’ draughtsman on the design of the United Nations Secretariat building—that shimmering monument to international cooperation with a smooth glass skin—, re-housed the factory typology within a glazed enclosure, marking the beginning of the KRJDA office’s technical research and material experimentation endeavors, a shift away from the more straightforward material applications of the Saarinen office and towards a more sinuous casting of building materials and techniques into instruments of commercial growth and global expansion within the shifting economic order of the late 1960s and 1970s.

**Cummins Walesboro: Materialized Transparency**

If at Darlington Cummins exploited the technical knowhow of the Saarinen/KRJDA office to serve its global expansion initiative by using the building’s technical perfection to represent and advertise the company’s expertise within new foreign markets, its subsequent diesel engine subassembly plant in Walesboro, Indiana (1970-1975), just
south of Columbus, sought a technically perfect enclosure for markedly different ends [Fig. 2.31]. There, precise techniques were employed not for their symbolic or representational import but rather to meet operational, spatial, and environmental exigencies internal to the company. Cleanly detailed glass envelopes worked to counteract the messiness of the era’s environmental, social, and economic conditions; the tightly defined enclosure at Walesboro was one component of Cummins’s far-reaching effort to inflect social relations both in internal business operations and within local and national communities. As the company became entangled within social processes at larger scales, part of the global shift to a neoliberal economy, the stakes of technical perfection shifted from direct material effects to a more pervasive mastery over material, infrastructural, political and social systems.

In a reflection of the circumstances of material and technical research during the late 1950s and 1960s, the glass shed at Darlington, using a detail borrowed from the GM Technical Center, formed a loose-fit container for industrial manufacturing. By the time KRJDA developed the transparent membranes of the Walesboro factory a decade later, a new, more convoluted model of technical development and business practice had emerged. Increased environmental constraints and regulations meant that the glass skins had to function as more precise environmental containers. At the same time, the Cummins corporation’s entanglement of commercial and social objectives hinged in many respects on novel spatial and environmental techniques developed for its company buildings.

Extensive glazing throughout the interior and exterior surfaces of the Walesboro factory was employed to intensify visual links between factory, administrative, and
managerial workspaces while offering all staff of the building immediate visual access to the exterior environment. The glazing techniques used embodied the Cummins corporate ethos, in that they maximized transparency beyond previously imagined limits, with the aim of reinforcing egalitarian relations between staff at all echelons, and increasing light levels and exterior views to improve the work experience. This was all part of the Cummins Engine Company’s strategy of corporate citizenship, which operated at a range of scales, from the context of the individual laborer in a factory space, to the towns within which Cummins operated, to national urban and social concerns. By the time the Walesboro plant was executed in the 1970s, Cummins was less interested in the symbolic or representational aspects of technical perfection than the ways in which tightly defined environmental enclosures could serve an expanding corporate mission. Architecture’s advanced technologies were cast primarily as a vehicle to foster progressive social change underwritten by commercial gains.

An article to be published in the November/December 1972 issue of the journal Material News detailed the design of Cummins’s building at Walesboro, “the world’s first ‘see-through’ industrial plant,” praising it as an industrial architecture prototype for its nearly exclusively glazed interior and exterior walls, which together comprised over 145,000 sq. ft. of glass. The tinted, solar-absorbing, reflective and tempered glass panels used throughout the building were all produced by Libbey-Owens-Ford [Fig. 198].

The article was intended to promote Dow Corning’s silicone sealant material. To maximize visibility, Kevin Roche John Dinkeloo and Associates (KRJDA) architects eliminated metal mullions from the glazed walls and instead specified that the building’s exterior and interior plate glass panels be affixed using a silicone sealant. Nearly 700 gallons of Dow Corning 781 RTV silicone rubber, an adhesive and sealant material developed purposely for glazing, were used to create butt and corner joints between panes of glass as well as to close off interior seals and jambs and exterior seals. The narrow silicone joints, 3/8 inches wide, formed vertical ‘pinstripe’ seams between the glass sections, creating the effect of an uninterrupted stretch of glass [Fig. 2.33-2.34]. The building’s north wall, composed of two tiers of glass 13 feet high and running the entire 1160-foot length of the building, appeared as a single expansive glass surface.200 In contrast to the caulk more commonly used to seal window joints at the time, the silicone sealant remained liquid at temperatures as low as 0°F, so glazing could be continued through the winter months, and the silicone material remained flexible, watertight, and weatherproof in temperatures ranging from -80 to 350°F, thereby accommodating expansion and contraction of glass panes, metal components, and masonry to ensure a


durable seal. Given the novelty of the silicone-sealed frameless glazing technique, KRJDA were required to submit detailed calculations demonstrating the safety of all glazing not supported at four edges [Fig. 2.35-2.36].

In comparison to early modern industrial buildings made of glass—German examples included Walter Beherens’s AEG turbine factory in Berlin (1909) or Walter Gropius’s and Adolf Meyer’s Faguswerk factory in Alfeld (1913), in the USA there was Albert Kahn’s Ford Factory in Michigan (1910), and in the UK was Owen Williams’s Boots Factory in Nottingham (1932)—the building form of the Walesboro, Indiana plant was intended to be even further dissolved through its sunken configuration and its unique frameless glazing. This visually dematerialized transparent building relied, however, upon very particular material and environmental techniques. Amid increasing fears over energy consumption in all-glass buildings, critics calling for more passive energy strategies viewed the kind of technical virtuosity of the frameless windows at Walesboro as a kind of endgame of the modernist impulse towards transparency.

The Corporation, c. 1970s

J. Irwin Miller’s dialogue with Roche and Dinkeloo on the relationship between material transparency, energy expenditure, and the workspace environment indicated not simply

\[201\] Ibid.


\[203\] See “Kevin Roche and John Dinkeloo, 1964-1974,” The Architectural Forum (March 1974), 49. Here the Walesboro building is described as a dematerialized factory form.
an interest in his company’s buildings, but rather this was part and parcel of his all-encompassing vision for Cummins’s engagement with social and political issues in all aspects of its material production. The cover of the October 1967 issue of *Esquire* magazine featured a headshot in profile of Cummins Engine Company chairman J. Irwin Miller, with the caption: “This man ought to be the next President of the United States.” A feature article, “Is It Too Late for a Man of Honesty, High Purpose and Intelligence to be Elected President of the United States in 1968?,” offered Miller as the ideal candidate to address the United States’ contemporary domestic and international concerns [Fig. 2.37].

Miller had joined the Cummins Engine Company, originally funded by his family, in 1934, becoming president in 1945 and board chairman in 1951. In this last capacity Miller had worked to develop a company strategy of progressive social policy through the internal treatment of Cummins employees as well as through the company’s outreach efforts to aid the larger communities in which it worked. It was Miller’s contention that large corporations had a responsibility to address the autonomy of the individual within the structure of the organization, as well as to participate in broader social efforts at the local and national levels. Calling for greater cooperation between business and government, he argued that business “should itself become the “revolution”

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204 Steven V. Roberts, “Is It Too Late for a Man of Honesty, High Purpose and Intelligence to be Elected President of the United States in 1968?” *Esquire* (Oct. 1967), 89-93; 173-185. Other suggested candidates included: David Rockefeller, president of Chase Manhattan Bank; McGeorge Bundy, president of the Ford Foundation; Joseph C. Wilson, chairman of the Xerox Corporation; C. Douglas Dillon, president of the United States and Foreign Securities Corporation and former Secretary of the Treasury; Robert S. McNamara, Secretary of Defense and former president of Ford Motor Company; Dr. Franklin Murphy, Chancellor of UCLA; Potter Stewart, associate justice of the Supreme Court; Henry Ford II, chairman of the Ford Motor Company; Hedley Donovan, editor-in-chief of Time, Inc.; and Edwin Etherington, president of Wesleyan University. Ibid., 91-92.
side and become an instrument of social reform and change.”

Miller was on of the board of directors of the Chemical Bank, A.T.&T., Purity Stores, Inc., and the Irwin Union Bank and Trust Company; he was also a member of the Yale Corporation [Fig. 2.38].

Miller had established himself as a consultant to the presidential administrations of Eisenhower, Kennedy, and Johnson by serving on a series of commissions dedicated to issues ranging from money and credit; the liberalization of East-West trade; health, manpower, and services; the post office; and the role of business in slum redevelopment. As the first layman president of the National Council of Churches, between 1960 and 1963 Miller pushed the organization to become a staunch ally of the national civil rights movement, and was one of three church leaders to organize the National Conference on Race and Religion in 1963. He helped to organize the March on Washington in the same year, and was an active advocate for civil rights legislation,

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205 A speech by Irwin J. Miller to a group of entrepreneurs quoted in Ibid., 181.
206 Roberts, “Is It Too Late…?,” 91.
207 Under Eisenhower Miller was appointed to a group dedicated to studying the status of money and credit which subsequently advised Kennedy on income tax laws. In 1965 Johnson appointed Miller chairman of a commission that recommended liberalization of East-West trade, which was reflected in legislation Johnson submitted to Congress. Around 1966 Johnson made Miller chairman of a commission to study health, manpower and services. In 1967 Johnson included Miller in a panel of 18 representatives of business and labor to “find the incentives which will stimulate business and labor to apply the most modern techniques, production systems, work practices, and economies of scale to the problem of the city slum.” See Lyndon B. Johnson. “Statement by the President Upon Appointing the President's Committee on Urban Housing. June 3, 1967.” See also “Panel to Study Trade with Reds,” The New York Times (April 5, 1965): 1, 18. See also Robert B. Semple, Jr. “U.S. Panel Named to Attack Slums: Johnson Appoints 18 From Business and Labor Areas,” The New York Times (June 4, 1967): 47.
which paved the way for the Civil Rights Act of 1964. Purportedly, Martin Luther King, Jr. described Miller as ‘the most progressive businessman in the United States.’

1967, the year the *Esquire* article was published, saw “The Long Hot Summer,” a chain of riots across the country to protest racial discrimination. In cities like Newark, Detroit, Milwaukee, and Cincinnati, increasing suburbanization and urban flight led to high levels of unemployment and social unrest in inner cities. As was the case with the General Motors Technical Center, industrial production facilities were increasingly relocated to sites beyond city limits, leaving urban centers in various states of decay. The 1967 Detroit riot, one of the most deadly and destructive in US history, was one of a string of demonstrations indicating that the social programs of the nation’s government, in terms of housing, schools, job creation, etc. were failing its most vulnerable populations, most notably African Americans.

Miller lamented the violence that African Americans had resorted to as the result of a loss of confidence in usual channels of negotiation and legislation. Describing American racism as “‘a sort of national insanity’,” he explained the unrest of 1967 as part of a “revolution of aspirations,” which fought for fair distribution of resources, equal opportunities for individual accomplishments, and an equal voice in the governing of society. Miller’s sympathy for the plight of African Americans, indeed any minority population, was uncommon amongst businessmen of the age, who tended towards libertarian ideology. While he supported the Republican Party, Miller refuted the notion of

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209 Roberts, “Is It Too Late for a Man of Honesty…,” 180-182.
that private entities would eventually resolve the United States’ pressing social and economic problems, and proposed that issues like racial disparity and urban blight required governmental intervention combined with the investment of private capital. This entanglement of private business interests with the structures and policies of government became a hallmark of Miller’s, and Cummins’s, operating strategy.

The Cummins Engine Company, led by J. Irwin Miller, positioned itself as progenitor of the corporate responsibility movement. Increasing profits throughout the 1960s had meant that Cummins could commit ever-greater funds to its philanthropic ventures through the Cummins Engine Foundation. Created in 1954, the foundation committed 5% of Cummins’ taxable income for philanthropic programs. It was most recognized for its architecture program, which covered the fees for notable architects to design schools, churches, a post office, and other public buildings for the town of Columbus, IN, where Cummins was headquartered.210 Throughout the 1960s, however, the company advocated greater involvement in national social concerns, especially civil rights and affirmative action, and Miller offered that it was in the self-interest of businesses to take on the social revolution: “Here is a place where I think business and the professions are often shortsighted. They somehow feel they can flourish regardless of what goes on outside their walls. Most of the groups that perished in the world felt that way.”211

211 Roberts, “Is It Too Late for a Man of Honesty…,” 182. Alfred D. Chandler argued that the American public tended to regard large-scale industry with skepticism, concerned that the democratic process was weakened when middle managers were legally unaccountable to the labor unions with which they interfaced. See Alfred D. Chandler, The Visible Hand: The Managerial Revolution in American Business (Cambridge, MA:
Miller himself seemed to be caught rather uncomfortably between the activist and capitalist agendas of his time. As president of the National Council of Churches he remained largely silent on inquiries by council staff activists into corporations’ social and political behavior, such as business dealings in the apartheid state of South Africa. While Miller occasionally praised this kind of activism, as a trustee of the Cummins Engine Foundation and the Ford Foundation he also refused funding to the church groups who researched and protested against questionable corporate practices.212

Within the context of individual private business operations, the notion of corporate responsibility offered a means for figures like Miller to try to reconcile their simultaneous involvement in political, social, and commercial spheres.213 Miller’s social views and advancement of ethical business practice were so influential upon the internal organization of Cummins that one measure instituted at the company in the late 1960s was referred to as the “Irwin Miller Transparency Test.”214 Under this metric, designed to ensure honesty in all contexts of business activity, if a proposed action—such as paying additional fees to middle men to expedite processing—could be rationalized to local clergy, then it was deemed acceptable. This transparency test was especially important

Belknap Press, (1977), 497. “The appearance of managerial capitalism has been, therefore, an economic phenomenon. It has had little political support among the American electorate. At least until the 1940s, modern business enterprise grew in spite of public and government opposition. Many Americans—probably a majority—looked on large-scale enterprise with suspicion. The concentrated economic power such enterprises wielded violated basic democratic values. Their existence dampened entrepreneurial opportunity in many sectors of the economy. Their managers were not required to explain or be accountable for their uses of power.”

212 Marylin Bender, At the Top (Garden City, N.Y.: Doubleday, 1975), 333-334.
214 Cruikshank and Sicilia, The Engine That Could, 320, 327.
for international dealings, which often involved local traditions and cultural norms that
diverged from company dogma on ethical practice.215

In 1968, the director of the Cummins Engine Foundation, Philip Sorenson,
proposed to focus the foundation’s efforts on race, poverty, and the
physical environment. To address problems of race the board approved the hiring of five
Foundation field officers to represent African Americans in major US metropolitan areas:
Los Angeles, Washington, Chicago, Detroit, New York, and Atlanta.216 Following
Sorenson’s departure in 1970 to become the chairman of Campaign GM, James A.
Joseph, an African American ordained minister in the United Church of Christ and a
pioneer of the corporate social responsibility movement, succeeded him.217 This was part
of a company-wide effort to recruit more minority employees. From 1965 to 1973 around
a hundred African American managers and executive trainees were appointed at
Cummins’s Columbus headquarters, bringing extensive experience from banking,
management consulting, board membership, etc. to their roles within Cummins; between

215 Ibid., 327.
216 Ibid., 322-323. There were hiccups in this program. Walter Bremond, the LA field
officer, had his house bombed by a group of black radicals in retaliation against his
mediation attempts. The president of an original equipment manufacturer (OEM)
complained to Schacht that he had been placed on a hit list by an activist organization
funded by a field officer, although this was shown to be untrue. Miller himself was
covertly investigated by spies on the Chicago police force because of a Cummins Engine
Foundation grant to the Afro-American Patrolman’s League, a group of black Chicago
police officers. On the other hand, working with the field officers gave white managers at
Cummins unprecedented contact with the experience of being black in America, which
was part of Miller’s objective in establishing the field officer program.
217 Joseph had worked as a leader in the civil rights movement before joining the
Cummins Engine Foundation in 1967 as associate director of the Association of
Foundations. He left for a stint as chaplain of Claremont Colleges in California before
returning to Cummins.
1972 and 1973, three corporate officer positions at Cummins were filled by highly qualified African Americans [Fig. 2.39-2.40].

In the spring of 1972 the Corporate Action Division (CAD) at Cummins was created, with Joseph as vice president. In many respects an effort to institutionalize the social values of Irwin Miller, ensuring that efficiency would be matched by responsibility, the CAD was dedicated to corporate philanthropy, governmental relations and public affairs, community relations, human resources development, and affirmative action programs. This was all framed as part of the company’s ‘enlightened self-interest,’ and CAD outlined its mission to operate as an internal resource “for understanding the social and political context in which the company does business.” In addition, the CAD was charged with ensuring that all business proposals—including new plants, market penetration schemes, and product development, etc.—would be accountable to Cummins’s corporate responsibility mission. According to Joseph, who viewed himself as a social scientist collaborating with business to discover channels for socially responsible practices, the locus for social change in the United States had shifted closer to the private sector: “In 1960 the arena for social change was the church and civil rights.

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218 Bender, At the Top, 331-332.
219 Cruikshank and Sicilia, The Engine That Could, 324. In this capacity Joseph reported directly to Henry Schacht, thereby making visible the power of his position at CAD.
221 Ibid., 325. Under the advisement of figures such as Charles W. Powers, a Yale professor who wrote the book, The Ethical Investor, the CAD developed a set of ethical norms to guide business activity at all levels of the company. Powers was tasked with heading a public responsibility unit to define Cummins’ responsibilities to public stakeholders, and Joseph recruited naval officer William Norman, a pioneer in integrating the US navy, to ensure that Cummins met its responsibilities to private stakeholders. See Joseph, Saved for a Purpose, 103-108.
The focus became the university. Now it’s clear that the center for power and the source of influencing change is the multinational corporation.”

Due to its size—in 1973 it was 234th on the Fortune 500— and its international scope, the social practices of the Cummins Engine Company attracted significant attention from the business world. Cummins pioneered the implementation of what came to be known as SMIRF, or the calculated use of social, moral, intellectual, reputational, and financial capital by philanthropic foundations.

The company’s affirmative action program was one element of a broader effort towards progressive policies to address issues of race, gender, housing, and the environment. While the Cummins Engine Foundation considered its architecture program as an effort to address the physical environment, and the program was lauded in the press for its support in the hiring of highly regarded architects to design a series of public buildings around Columbus, in fact Cummins’s own buildings to accommodate production and administrative functions were even more directly reflective of the company’s environmental and social ethos. If discussions surrounding projects in the Cummins architecture program centered on ‘good design’ and purely aesthetic preoccupations, the architecture of Cummins’s own buildings was understood to

222 James A. Joseph quoted in Bender, *At the Top*, 347.
encompass the aims of both the Cummins philanthropic foundation and the company’s business operations.

Writing about affirmative action program instituted by Cummins in the late 1960s and early 1970s, New York Times reporter Marilyn Bender argued that internal acceptance of newly recruited black employees, who were sometimes spurned by existing workers, “was encouraged somewhat by the corporate policy of at least surface egalitarianism in other areas.”225 Listing the elimination of reserved executive parking spots and washrooms, and the opening up of executive offices to create links to other workspaces, Bender reported that the architecture of the company buildings was devised to effectuate a widespread acceptance of the new social order. That ‘surface egalitarianism’ indicated an effort towards fair treatment of individuals to instill a sense of fulfillment and autonomy that could be detected at various levels of intervention, from the scale of an office enclosure, to the organization of a factory, to the public spaces of a small town, to mass housing and urban blight. At the same time, at least rhetorically, ‘surface egalitarianism’ epitomized a tension between the benevolent aims that the company promulgated and its commercial purpose. To what degree was Cummins’s social progressivism a gloss over, or advantageous partner to, its tactics for financial gain? Cummins’s social mission—at once earnest and self-serving—mirrored the slipperiness of the emerging neoliberal order.

Increasing social unrest in the late 1960s over unemployment, inflation, racial discrimination, and the specter of war, combined with a weakening confidence in institutions, made evident a crisis in the embedded liberalism that had developed in the

225 Bender, At the Top, 336.
immediate postwar period. While Keynesian practices adopted in the United States and Europe after World War II held that societal improvement came from governmental intervention in social and economic policies, by the late 1960s the growth such policies had brought about began to slow. Increased unemployment coupled with inflation produced ‘stagflation,’ and the early 1970s saw a move towards a neoliberal political and economic structure, in which states largely removed themselves from the development of any social programs.\(^{226}\) The philanthropic endeavors of the Cummins Engine Company Foundation, and Miller’s optimistic view of corporations’ capacity to assume the kind of social responsibilities once reserved for the state, took place within the context of this dissipation of the public sphere and a shift towards private influence over social programs. Indeed, notions of enlightened *self-interest* and corporate *responsibility* denoted a concentration of power in the hands of financial elites who, while not elected by any democratic process, had the capacity to influence national governmental policy on issues ranging from international trade, to racism, to housing, as Miller in fact did.\(^{227}\)

**Industry, Labor, and Environment**

During the late 1960s and early 1970s Cummins’s support for environmental regulation exemplified its practice of progressive social responsibility and enlightened self-interest. The company’s 1970 annual report stated that while federal agencies should sympathize


\(^{227}\) Miller also fought against discriminatory housing policies in Columbus, worked towards increased voter registration, and apparently defended his company against anti-Semitic and racist threats. Miller also supported programs to hire Vietnam veterans as well as those imprisoned as conscientious objectors, and he urged the company to hire women at all levels. See Cruikshank and Sicilia, *The Engine That Could*, 238-239, 321-322.
with the pace of commercial development, “the needs of the society transcend the individual needs of any one manufacturer, including ourselves.” In a display of its commitment to the preservation of the environment, Cummins had helped to support the 1970 amendments to the Clean Air Act, which established the Environmental Protection Agency as well as federal and state emissions standards to combat air pollution.

Cummins argued that manufacturers were duty-bound to achieve these standards using their own resources; even though socially acceptable power sources would cost more to produce than previous engines, a polluted environment would exact a greater toll over all. All Cummins engines produced in 1970 met the proposed 1973 California standards, and the company was working to meet more stringent 1975 standards. This was presented to shareholders as a matter of self-interest as well as a responsibility to society at large:

This is a race in technology. For the company who continuously meets, ahead of time, needed standards of environmental quality and of lowest total cost, the rewards can be very great indeed.

In all of this a central purpose of this Company is to anticipate the changes taking place in our society and to pursue that course of action which will meet our responsibilities to all whom our actions affect.

The 1970 Cummins annual report presented the company’s plans for expansion, framing concern for efficient manufacturing spaces within the context of its broader environmental program. Productive capacity was projected to increase by over 50 percent between 1969 and 1972, and the largest single facility in this endeavor was the new 572,000-square-foot machine and subassembly plant in Walesboro, Indiana, designed by KRJDA. The project broke ground in the fall of 1970, and the annual report proclaimed

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229 Ibid.
the project’s emphasis on environmental quality both for the work force inside and for the landscape surrounding the building. This was a primary instance of a company-occupied building devised to advance the environmental, social, and commercial missions Cummins had laid out.

Architects and client alike emphasized the light hand taken with regard to the rural landscape, minimizing damage to the existing ecology of arable farmland [Fig. 2.41-2.42]. The subassembly plant was sited on a swath of previously cleared wooded land, and was partially sunken seven feet below ground level to sit low on the horizon, with excavated earth banked up on the exposed side of the building to minimize its visible presence in the landscape. Because it required a robust roof structure to support the heavy cranes used to manufacture diesel engines, the building easily supported rooftop employee parking for 1400 cars, thereby avoiding the need for extensive impermeable paving that would have occupied around the same footprint as the building itself. A 2,000-foot-long screen of translucent glass concealed the cars on the roof from passersby on the adjacent highway [Fig. 2.43-2.44].

Where it was not submerged and held by retaining walls, the factory was sheathed in transparent and translucent glass—“the world’s first ‘see-through’ industrial plant”—an unexpected use of the material both for its presence within the agrarian landscape, and for its application in industrial manufacturing. In their own descriptions of the project

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230 Ibid., 17.
231 Project Description: “Cummins Engine Company Sub-Assembly Plant. ” Yale University Archives, MS 1884, Box 384, Kevin Roche John Dinkeloo and Associates records, Project Records. 7003 Cummins Engine Company Sub Assembly Plant, Project Statements, July 1987, no date.
232 “GLASS – ENCLOSED CUMMINS ENGINE PLANT IS INDUSTRIAL ARCHITECTURE PROTOTYPE.” Article draft for Nov./Dec. 1972 issue of Material
Cummins fore-grounded the building’s externally focused configuration, made possible by its transparent envelope, to provide visual links to the woods bordering three sides of the building. A central design conceit was that all 2100 employees, even those in the boiler room, would be given direct external views. The interior of the factory was configured so that no part of the workspace was more than 90 feet from an uninterrupted view to the outside. Because the building was partially buried, eyelevel in workspaces along the building’s periphery aligned with the ground plane outside, this shift in perspective forcing a reconsideration of the connection to the exterior world [Fig. 2.45-2.47].

Production facilities, more commonly buried in the depths of windowless sheds, were distinguished from office spaces by a sectional shift and by low partitions, so that visual links between the manufacturing floor at the heart of the building and the landscape at its edges would be maintained. Glass-roofed cafeterias positioned at the building’s corners were apparently intended to impart a picnic atmosphere, and glass-enclosed escalators on the ends of two internal courtyards gave access from the rooftop parking to the submerged production floor [Fig. 2.48-2.49]. Positioned in section halfway between the parking and production levels and located at the center of the building’s manufacturing zone, these planted courtyards offered a green space for employee breaks.

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and were lined with glazed walls to provide additional illumination for production spaces inside [Fig. 2.50-2.51].

But what do we make of this preoccupation with bridging interior and exterior worlds? How did this effort to visually link manufacturing zones with green space serve to reinforce Cummins’s mission of environmental improvement, and what did environment really mean within this context? While the transparent envelopes forming the courtyard spaces certainly enhanced visual connections to the outside world, as Cummins asserted, they were particularly telling about the status of environmental management in the early years of the 1970s. At once transparent and submerged, the factory was presented as a “non-building.”

In concert with the other glazed facades, the very thinness of the courtyard’s glass walls, and the elimination of metal mullions, generated a prototypical seamless membrane intended to disintegrate the material barrier between interior and exterior [Fig. 2.52]. The layered glass skins at Cummins Walesboro created an internal world that operated as a testing ground for strategies of energy efficiency and environmental protection, as well as for the corporation’s policies on the social organization of the labor force, thereby bridging between a representational treatment of architecture and a more operational, managerial approach. This model of containment reflected a shift in Cummins’s conception of productive workspace, and its position relative to the broader commercial-philanthropic sphere that the corporation promoted [Fig. 2.53]. As such, it repackaged “environment” as an entity that could

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236 Charles Hoyt, “Productive Elegance for Industry,” *Architectural Record* 158, 1 (July 1975), 126. The Walesboro plant was described here as a “non-building,” whose protruding high bay for storage occupied only 10 percent of the building area.
simultaneously enhance manufacturing processes, internal company relations, and the external image of the company. Rather than considering environment as something to be merely controlled for purposes of comfort and cost savings, Cummins incorporated environmental management into a strategy for commercial prosperity, in terms of a controlled interior atmosphere, but also in terms of the way in which environment came to be represented through its very precise techniques of enclosure.

The corporation framed its efforts to offer pleasant, clean, and healthy workspaces as one component in a sweeping endeavor to optimize environment for the benefit of an increasingly fulfilled and diverse workforce: “American industry has historically been very good at designing spaces in which production equipment can operate efficiently. A much more important concern in the future will be to provide spaces in which human beings can work effectively and happily.” To this end, Cummins embarked on a program for environmental management: “Perhaps the area of greatest concern is not one affected by government legislation or public pressure—interior environment. Cummins feels an obligation to provide good working conditions for employees. Therefore, some of our largest expenditures are for the elimination of dirt, dust, oil mist and noise and the addition of air conditioning, cleanliness, better lighting and other employee conveniences.” Completely air-conditioned and climate controlled, the Walesboro plant was equipped with custom designed dust and oil-mist filters to provide the most

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237 Cummins Annual Report (1970), 18. Exterior exhausts for the factory were to be thoroughly scrubbed and filtered, and the building’s four sewer systems would treat manufacturing waste like oil and detergents from wash tanks before releasing them to the city sewer.

238 Ibid. Exterior exhausts for the factory were to be thoroughly scrubbed and filtered, and the building’s four sewer systems would treat manufacturing waste like oil and detergents from wash tanks before releasing them to the city sewer.
comfortable interior environment possible. These improvements to the workspace environment were coupled with a program intended to increase employee satisfaction by providing opportunities for growth and development, especially in manufacturing divisions, and ultimately to realize a “competent, stable and highly flexible workforce” where workers felt the capacity to reach their potential in an “individually rewarding” environment [Fig. 2.54-2.55]. The recruitment of minority employees was considered an integral component of this program to improve the space of labor.

J. Irwin Miller and the Cummins board of trustees viewed architecture as an instrument for increasing diversity and satisfaction among the employee body, and Miller apparently remained fully involved throughout the design process for Cummins buildings. During the design of the Walesboro plant Cummins for the first time consulted employees to generate ideas for workspace improvements, a procedure that would subsequently become standard practice in the design process for any Cummins production or office facility. Rather than specify a particular aesthetic or even a specific organizational system, Cummins claimed, they preferred to allow architects to develop new design ideas to reinforce the central goal of improving the interior

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239 Ibid., 16. In 1970 the Cummins workforce comprised 11,500 people worldwide, 8,500 of whom were based at the main plant in Columbus, Indiana.
240 Carleton Knight, III. “J. Irwin Miller: Patron, Client, But Always Businessman,” *Architecture* (June 1984), 64. Kevin Roche stated of Miller: Kevin Roche stated: “‘Miller’s favored method is to ask questions of his architects. ‘It forces people to think and consider the consequences,…It can be exhausting, making you question your own motives…He sees architecture as an extension of his humanist viewpoint,…He knows very well what goes on on the factory floor. He has a good feel for working conditions and wants to improve the whole work environment.’”
241 Ibid., 64-65. Peter Eisenman described the design process for a Cummins plant in Madison, Indiana, as “‘an incredible sociological experience.’” The only problem, according to Eisenman, was that the programming phase of the project was so complex that the technologies it accounted for were obsolete by the time programming was complete.
And yet, there were certain consistent material and aesthetic traits in the projects that KRJDA completed for Cummins.

While the Cummins plant at Darlington, England had maximized transparency to improve workers’ visual access to the outside, the Walesboro subassembly plant assumed a much more complex configuration. Discussions between client and architect surrounding the design of the interior space at Walesboro centered on questions of environmental comfort and the management of energy systems; this coincided with a shift in the work of KRJDA towards a complex layering of interior and exterior spaces, as well as the pursuit of an ever-thinner membrane between the two. Here, the interspersing of conditioned enclosures with exterior spaces served the aim of improving the experience of industrial workers by breaking down visual barriers to the outside world, but at the same time the glazed factory walls discretely contained a fully controlled interior atmosphere designed to enhance productivity and job satisfaction. New techniques for glazed envelopes enabled a more complex iteration of the nested interior configuration that KRJDA had begun to develop in previous projects, and the environmental management of the workplace—accounting for atmospheric comfort, energy costs, and the impact of the factory on its natural surrounds—was manifested in the building’s material presence [Fig. 2.56-2.58].

Smallness and Bigness, Microcosms and Megamarkets

Using layered glass surfaces to create a double interior became a signature of the KRJDA

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242 Ibid., 65. James E. Shipp, vice president for corporate facilities, explained that Cummins once attempted to draft a set of design guidelines for architects but couldn’t agree on any they all seemed to limit the introduction of new ideas.
practice’s projects for corporate workspaces. In this configuration, the natural world—in the form of greenery, fountains, and landscaped grounds—was reinserted within the confines of a building’s glazed walls to form an interior environment intended to ameliorate conditions for employees confined to a building for increasingly long workdays [Fig. 2.59].

This interior configuration was frequently compared to the glass greenhouse typology, notably in reviews and criticism of the Ford Foundation Headquarters in New York City, completed in 1968, a 12-storey building which contained a full-height planted and landscaped atrium designed by Dan Kiley [Fig. 2.60-2.61]. In an essay entitled “Greenhouse Architecture: Notes on a Genesis of Form for Roche-Dinkeloo’s Recent Work,” Museum of Modern Art curator Ludwig Glaeser placed KRJDA’s oeuvre within a lineage of utilitarian glass buildings which, he argued, had inspired the glass skins of modern architecture. He asserted that the sharply angular forms and pristine planes of the Ford Foundation building’s glass roof drew directly from the ridge and furrow patent glazing typically applied to 19th century greenhouses, and suggested that KRJDA exploited glass’s material attributes of flatness, smoothness, and transparency—which obviated any interruptions in a surface to make windows or doors—to develop muscular, monumental, object-like forms. Even beyond formal aspects, however, the greenhouse

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243 Roche later distanced himself from the all-glass buildings for which the KRJDA practice became so renowned, such as the gleaming mirrored for UN Plaza towers they designed in the late 1960s: “The UN Plaza buildings…belong to another time…I have no ambition to spend the rest of my life building buildings that look like that.” See Walter McQuade, “Born again: Kevin Roche, architecture’s last puritan turns populist,” Connoisseur. 218, 913 (Feb. 1988), 87.

typology was a particularly germane reference for KRJDA’s work according to Glaseser because it used a range of building forms to develop artificial climates or controlled environments [Fig. 2.62].

Certainly, the introduction of lushly planted gardens and waterfalls within the atrium of a New York office building provided atmospheric relief, but it also presented a controlled natural world that served as a spatial buffer between the operations of the Ford Foundation’s administrators and the urban exterior of the Manhattan grid. Founded in Detroit in 1936 and moved to Manhattan in 1953, the Ford Foundation was a major grantor of American developmentalist programs, and a progenitor of the corporate social responsibility movement, embodying the entanglement of business interests with philanthropic ventures in this new partnering of government and corporations on national and international social missions. J. Irwin Miller himself instantiated the interconnectedness of the corporate-philanthropic realm in his role as a trustee of the Ford Foundation, where he oversaw an increase in its contributions to anti-poverty, community organization, and civil rights efforts.

an architecture that attempts a new geometric monumentality, and projects the coordinates of minimal sculpture onto a heroic scale.”

Ibid., 84. Acknowledging the problem of sun control in glass buildings, Glaeser suggested that the ability of glass to trap heat might render the greenhouse a model for future energy conservation: “Without question, Kevin Roche has made the most important architectural contribution to the current revival of the glass enclosure…The energy crisis may in many eyes turn this preoccupation into last glances at a doomed species of buildings…Still the current economic conditions may just prove to be another challenge for technological advances on a broader front. Since greenhouses are by nature heat traps, practical ways of storing and using solar energy could be developed with their application.”

See Steven V. Roberts, “Is It Too Late for a Man of Honesty, High Purpose and Intelligence to be Elected President of the United States in 1968?” Esquire (Oct. 1967), 182.
There was a unique tension between the United States automobile industry—a major component of what Eisenhower had termed the “military-industrial complex”—, increasing social unrest in American cities, and the emergence of global corporate philanthropy. Just as the Ford Foundation’s new headquarters building was being completed in Manhattan, the 1967 riots in Detroit demonstrated the impact upon inner cities that the automobile industry’s growth and expansion had had when it moved outside the bounds of American cities into the new industrial landscape of the Midwest. The Ford Motor Company was part of this movement, which the Ford Foundation then paradoxically worked to ameliorate though programs intended to assimilate urban African American communities within the established national economic and political order through technical assistance by social science experts, a domestic application of its developmentalist mission.

\footnote{See reading copy of President Dwight D. Eisenhower's Farewell Address on January 17, 1961, p. 13-15, accessed Oct. 9, 2016. \url{https://www.eisenhower.archives.gov/research/online_documents/farewell_address/Reading_Copy.pdf}. “We annually spend on military security more than the net income of all United States Corporations. This conjunction of an immense military establishment and a large arms industry is new in the American experience…Our toil, resources and livelihood are all involved; so is the very structure of our society. In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex.” As an example, Robert S. McNamara went from being President of the Ford Motor Company (1960), to U.S. Secretary of Defense (1961-1968), in which capacity he notoriously orchestrated the Vietnam War, to President of the World Bank (1968-1981).}

\footnote{See Karen Ferguson, “Organizing the Ghetto: The Ford Foundation, CORE, and White Power in the Black Power Era, 1967-1969,” Journal of Urban History 34, 1 (November 2007), 70-87. Ferguson argues that Ford Foundation officers identified a black cultural pathology in the United States, stemming from its history of slavery, which could only be overcome through philanthropic missions emphasizing ‘technical assistance’ from Ford Foundation staff and social science experts. This domestic program, according to Ferguson, was akin to the Foundation’s international development programs offering technical concepts and methods to ‘native’ communities. See Ibid., 86.}
Unlike the United Nations Secretariat building down the street, a tautly contained
glass box that reflected its urban surrounds on its expansive glass facades and aimed to
provide flexible control of interior conditions, the Ford Foundation headquarters offered a
new spatial model for managing both interior environments and global development. If
the 19th century greenhouse typology housed species from various habitats under one
roof, in effect bringing the world home to the colonial metropole, the controlled
atmosphere of the Ford Foundation’s central internal court with greenery and waterfalls
served to naturalize an emergent model of liberal developmentalist philanthropy. And
while the United Nations organization had helped to define the international sphere in the
immediate postwar years, the Ford Foundation was more closely linked to the global
order of the late 1960s by successfully confounding the categories of the universal and
the particular—or homogenization and heterogeneity—in its creation of a space that
fused global exterior with a new form of interiority to accommodate corporate
philanthropy [Fig. 2.63].

The architects’ stated motive in the Ford Foundation project was to provide an
alternative to a typical speculative office building, which would be built to maximum
allowable height, with a central core ringed by workspace and all offices with exterior
views reserved for executives. Roche critique the monotony of the typology: “We’re
going to rise out of the ground, in effect, and the high-priced help will have a view; this

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works beautifully in theory, until everybody does the same thing. They all go to their windows, and they all look out and see windows!“\textsuperscript{250} In order to overcome the problem of the compartmentalized individual office worker confined to an isolated space with a view out to the city, but whose only means of communicating with colleagues was through electronic instruments, KRJDA created a mid-height building with glass-walled workspaces facing a planted interior atrium. The openness of office spaces and the expansiveness of the interior garden were intended to foster visual and spatial connections between workers; according to Roche, “we ended up with a solution which creates its own environment.”\textsuperscript{251} However, this environment had less to do with atmospheric regulation—heating, ventilation, and air-conditioning—than it did with communication.

Roche made the case that the Ford Foundation’s planted atrium permitted social interactions between employees from various departments dedicated to different issues and geographic regions who would previously have been housed on different floors with little opportunity to meet, so that the organization of the building’s interior would quite literally allow for more harmonious management of global philanthropic programs. This resonated with the concept behind the adjustable climactic controls at the UN Secretariat, but there international diplomacy was to be fortified by adjacent and heterogeneous microclimates to accommodate the differing environmental requirements of bodies with diverse global origins. At the Ford Foundation building, by contrast, a central shared “natural” or “green” space was meant to enhance the organization’s endeavor for greater

\textsuperscript{251} Ibid., 70.
communication with and between global regions, a foundational principal of its efforts to underwrite worldwide economic and technological development [Fig. 2.64].

If interiority at the Ford Foundation was primarily about enhanced communication—as opposed to an externally oriented building organized around a hierarchy of status—this was to service the organization it contained. Interactions between individuals working in various global development programs would reinforce the Ford Foundation’s mission, which in turn bolstered the neoliberal economic policies advanced by the American military-industrial complex. Emerging from this spatial and political lineage, the Cummins Walesboro plant carried the notion of interior communication further; its convoluted relationships between technical, social, and natural spaces provided a model for larger scale environments of social integration, of the kind supported by philanthropic organizations such as the Ford Foundation. There, the spatial, material and atmospheric techniques of architecture were used to further a growing corporate-industrial-philanthropic agenda.

Following on the completion of the Ford Foundation headquarters, the Cummins Walesboro plant cemented KRJDA’s design approach by further developing this new architectural order of interiority. Rather than a revision of the 19th century greenhouse typology, the layered glazed skins and nested interior spaces at Walesboro are more accurately considered a materialization in miniature of the corporation’s expansive social, political, and environmental agendas. Peter F. Drucker’s theory that the social organization of a corporation formed a microcosm of society at large was reflected in Cummins’s spatial configuration and environmental management of the industrial workspace in its Walesboro facility to provide a model for the corporation’s relationship
to the broader world within which it operated. Through its material techniques of enclosure and its environmental systems, the building begat a corporate space that employed environmental regulation to better fulfill a diverse employee population while simultaneously enhancing industrial productivity, commercial gains, and the worldwide image of the company. This was not an enclosure that condensed or simulated other far-flung spaces—the antipodal nodes of empire brought home—but rather one that modeled spatial and environmental structures to be projected globally. The model of interiority at Cummins Walesboro operated as a microcosm expressly because it was to be replicated and circulated at a range of scales. As Cummins expanded its worldwide business operations and its national social reach, this microcosm was to be translated and transmitted both domestically and internationally [Fig. 2.65].

Scalar relationships were a consistent theme in the discourse surrounding KRJDA’s work. Vincent Scully emphasized problems of legibility and representation, arguing that KRJDA’s projects all shared the characteristics of “scalelessness, avoidance of detail where it can reasonably be avoided, absolute abstraction, disquieting remoteness…” For Scully, the lack of articulated detail between surfaces and the

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252 See Peter F. Drucker, The New Society: The Anatomy of Industrial Order (New Brunswick, NJ; London, UK: Transaction Publishers, 1993), 151-152. The book was originally published by Harper in 1950. Drucker wrote: “The ‘cash nexus’ of the economist is not really a ‘nexus,’ that is a bond, at all. It does not make the individual a member of the enterprise. It does not satisfy the individual’s demand for social status and function…Whatever the form, the essence is that the individual’s social position represents, as in a microcosm, the structure of his society; and that the social order mirrors, as in a macrocosm, the basic convictions regarding the nature of man which this particular society holds.” See also Scott R. Bowman, The Modern Corporation and American Political Thought: Law, Power, and Ideology (University Park, PA: The Pennsylvania State University Press, 1996), 201.

object-like forms of KRJDA’s buildings produced a sense of unreality and alienation:

The first problem we have with Roche-Dinkeloo’s work is that of scale. How big is it in relation to us and to everything else? Normally we have no idea…One reason for the problem…is the stark simplicity of the basic shape whether large or small. It gives us no subsidiary scale of reference within itself. Along with this goes a uniform absence of what might be called qualifying detail. No intermediate changes of plane lead from one major element to another, from wall to glass, for example. They are juxtaposed without the complication or the celebration of that event. Therefore all the buildings look like models; their intersections give the impression of retaining at built size only the articulation in detail that those of a model can easily possess.\(^{254}\)

Scully criticized KRJDA’s borrowing of highway construction techniques in projects such as the Ford Foundation as anti-humanistic and “technocratically formalistic,” producing idealized abstract forms that had little to do with human experience.\(^{255}\) He called the greenhouse a “Roche-Dinkeloo Ideal,” claiming that the architects clung to the precedent of Paxton’s Crystal Palace, persistently refashioning the typology at ever-larger scales to make their buildings “even more generalized in detail, tauter, more elegant, and

\(^{254}\) Ibid., 18. Scully continues, “Another reason for the scale problem is the schematic nature of the designs. Each embodies a large and simple Idea: not, it must hastily be said, a sentimentally literary one like so many of Saarinen’s, or an agonizingly sculptural one like some of Paul Rudolph’s, but an Ideal concept none the less, and always a very abstract one, a rigid schema beyond qualification, uninflected by any feeling for human happenstance or foible.” Scully compares this abstract form-making to the “purely geometric intrusions we find in some of the paintings of Magritte, arrestingy alienated in the more complexedly detailed and scaled urban landscape.”

\(^{255}\) Ibid., 20. “Take the semiologists’ current concern for Road symbolism, for the Thruway and the Highway, and what can be seen from them. Take that interest and turn it around to focus on the Thruway not in terms of what is around it but of how it is constructed, especially its great bridges and overpasses. True enough, the approach to form is in this case not a humanistic (man- and use-centered) but a technocratically formalistic one…All these highway-inspired buildings are clearly schema, idealized abstractions applied to their particular functions—or, it would be truer to say, abstractions which are nevertheless made to house their functions very well indeed.”
more pristine.” Scully’s depiction of the consequences of architectural scale in terms of external expression clashed with the architects’ own interpretations; Kevin Roche continually resisted aesthetic or image-based analyses of his work. For him, the significance of scale in architecture was the ability to produce spatial progressions between an individual, a corporate organization, a city or landscape, and a society at large, and he claimed to move fluidly between the massive, abstract scale of highway construction, upon which the Ford Foundation was based, and the human scale of the individual. What, then, did Roche’s attempt to accommodate the space of the individual within a comprehensive corporate and societal organizational structure imply for architecture’s role in articulating the standards and ideals of corporate clients using spatial, material, and atmospheric means?

In a 2006 interview Kevin Roche addressed the problem of scale when he mourned architects’ gradual relinquishing of control over the details of building design over the period from 1945, when he began his career, to the present. Ruminating on the

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256 Ibid., 20. Scully described the greenhouse as “no less abstracted” than the highway, but “more conceptually and visually sympathetic to most of us at the present time.” He explained the import of Crystal Palace as “the great house of sunlight which was to shelter us all in the glorious future, wholly liberated from the somber prisons of the past.”

257 See Roche, Kevin, John W. Cook, and Heinrich Klotz. “Interview with Kevin Roche, 2006,” Perspecta 40 (2008): 114. “I use that analogy of the ‘highway scale’ in a building such as the Ford Foundation, which has two different aspects to it from an urban design point of view. It has 42nd Street, which is a large-scale street, and then it has a medium-height residential area adjacent. I use that as a contrast in development to the idea of accommodating the individual. How do you deal with the individual, the one person who is committed to that boring day-in and-day-out—working at a desk or now staring at a computer—how do you make something which accommodates the worker and gives a little aspect to his or her life?”

258 Kevin Roche, John W. Cook, and Heinrich Klotz. “Interview with Kevin Roche, 2006,” Perspecta 40 (2008), 115. “…when I started working in architectural offices in 1945 you pretty much had to invent everything from door handles, to door knobs, to hinges. There wasn’t anything off-the-shelf. There was no such thing as a Sweet’s
architect’s lost capacity for material and technical invention at the small scale, Roche stated:

There was once a time when an architect had a position in society and in the culture, where people recognized that the architect had a right to make decisions and could be relied on to produce a significant work of art. Nowadays you, as an architect, get pushed around by the client—very severely—as if you were a draftsman and didn’t really have any particular skills. It is as if all you are bringing to the table is your ability to work on the computer, and the client is going to make the decisions for you. This is also driven by the commercialization of buildings being built for profit. When they are being built for profit, the person who is in charge of the profit aspect of the project is a controlling voice.²⁵⁹

With large corporate clients, and increasingly substantial budgets for building projects, the architect was given less control over small-scale decisions, which for Roche implied a loss of professional stature. The architectural details and environmental configurations that his firm had developed for such clients were treated as part and parcel of comprehensive commercial strategies for businesses that in turn relied upon increasingly expansive organizational structures.

As the controlling voice of the Cummins Engine Company, J. Irwin Miller was similarly vexed by the tension between bigness and smallness, as the interests of large-scale business operations seemed to conflict with concerns at the level of the individual in society. For business, large-scale growth meant loss of attention to small-scale participants in the process. On the problem of maintaining a focus on the human within the context of ever-larger institutions, Miller argued in 1967 that the increasing size of

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²⁵⁹ Ibid.
corporations could potentially aid their ability to work with government on addressing national social problems:

I think we’re suffering some of the pangs of bigness, and growth, and impersonality, but you can’t avoid being big. So many of the undertakings you want to accomplish in this society can’t be accomplished except by very large groups. Even the New Left wants the things made by the assembly line of the education at a large university. You’ve got to solve the problem of how you take on a big activity, but make bigness your servant, not your master.²⁶⁰

Describing the failure of liberal economic policies enacted by western nations in the aftermath of the Second World War, Miller asserted that large-scale corporations were the precise entities equipped to address the state’s loss of control over overarching social and economic concerns: “…the size and complexity of the nation is such that government isn’t big enough to solve the problems, and that many of the problems can’t be solved except by using the enormous potential of the private sector.”²⁶¹

At the same time, American corporations were forced to confront even larger scalar effects during the late 1960s and early 1970s with the emergence of global mega-markets that impacted their industrial practices and their organizational structures. While the early years of the 1970s saw simultaneous recession and inflation, the energy crisis, and increasingly obfuscated Wall Street dealings, in addition to the emerging threat of foreign competition, Cummins maintained an escalating pace of growth. It took 47 years

²⁶⁰ J. Irwin Miller quoted in Roberts, Steven V. “Is It Too Late for a Man of Honesty, High Purpose and Intelligence to be Elected President of the United States in 1968?” Esquire (Oct. 1967), 181.
²⁶¹ Ibid., 182. Miller described the postwar turn to embedded liberalism as a preface for his argument regarding the contemporary need for private investment in social institutions: “In the Thirties, we felt that the private system had broken down, and that the answer under the New Deal was for the government to solve large areas of problems. This was done, and much of it was absolutely essential. I think we are now about to make another discovery.” On postwar embedded liberalism see David Harvey, A Brief History of Neoliberalism (New York: Oxford University Press, 2005), 7-13.
to build the first 500,000 engines, (from 1919 to 1966), but the next 500,000 were completed in only 8 years; between 1969 and 1974 sales increased from $392 million to $802 million. Cummins had begun expanding into developing markets in the early 1960s, opening its first diesel engine operation in India in 1962. The 1971 Annual Report laid out the company’s plans for worldwide expansion, which acknowledged both an opening up of new markets and increased competition for market share in developing nations, as well as a future scarcity of worldwide resources. In order to meet changing market demands in rapidly developing nations, Cummins proposed creating a cohesive international network of manufacturing plants to diversify its operations across a global geographic field while capitalizing upon worldwide power businesses.

At home in the company’s Columbus, Indiana headquarters, cleanliness and an orderly appearance were paramount. Cummins stressed superlative precision in production, and maintained unusually high standards in its manufacturing workspaces, where an improperly tightened bolt or a component misplaced on the assembly line were cause for serious reprimanding. The Wall Street Journal depicted the Columbus manufacturing facility: “The main plant is still scrubbed as much as some restaurant kitchens. The clutter of newspapers isn’t allowed during breaks on the line, where

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263 Cummins Annual Report (1971), 7-8. The report described “opportunity in the form of new markets and challenge in the form of aggressive, awakened nations and work forces offering new competition.”

264 Ibid., 9-15. The report names Cummins’s plan to maximize the worldwide power business by attempting to dominate the North American truck market, industrial and marine markets, higher horsepower engine markets, the Mexican truck market, the UK truck and construction equipment markets, the Japanese market, the South American truck market, and the Indian market, etc.
reading is limited to the bible and technical manuals.”265 This high degree of control over the industrial environment—technically, aesthetically, and socially—was linked to an unusually technically perfect product. Only 1% of engines completed in its plants needed to be reworked, compared to around 3% on average in the industry.266

From the 1960s through the 1970s Cummins used precision as an antidote to bigness. The company’s production model relied upon cleanliness, order, and a high degree of control over the environment to achieve an unusually precise product and maximum output volumes for increased profits [Fig. 2.66].267 In the early 1980s, however, when foreign competition from companies like Nissan took advantage of newer factories and cheaper labor to offer 20% reductions in prices, conventional industrial profit models foundered.268 Cummins’s localized concentration on localized and relatively small scale were no match for a stock market that privileged quick profits through abstract models of profit and financing over more long-term gains from material manufacturing. At the same time, Cummins’s own production system was becoming more convoluted, as component manufacture and engine assembly demanded networked

266 Ibid. “The company’s emphasis on quality has taken on Cult dimensions here. Charles Kessler used to gather his factory-floor trainees around to shame any one of them who failed to properly tighten a bolt, and the late manager V.E. MacMullen ranted at so much as a momentarily out-of-place oil pan on the assembly line.”
267 Ibid. “Only 1% of engines completed in its plants needed to be re-worked, compared to around 3% on average in the industry. “The company’s emphasis on quality has taken on Cult dimensions here. Charles Kessler used to gather his factory-floor trainees around to shame any one of them who failed to properly tighten a bolt, and the late manager V.E. MacMullen ranted at so much as a momentarily out-of-place oil pan on the assembly line.”
268 Ibid. The article quotes Harvard political economist Robert B. Reich on the economic changes of the 1980s: “‘This decade shattered a comfortable world where manufacturers improved profits by doing what they always did—just more of it.’”
relationships between plants and distribution facilities located across the globe. Rapid increases in demand stressed the links in this system, and the company faced greater difficulty keeping pace with production schedules.\textsuperscript{269} While Cummins attempted to face off Japanese competition, its main competitor Caterpillar gained an additional 20 percent of the heavy-duty truck market between 1978 and 1988.\textsuperscript{270}

In 1974 Cummins had faced a crisis of inventory, when it ballooned to levels 80 days ahead of schedule. There were also discrepancies between materials management records and financial accounting records, resulting in so much missing inventory stock that the company began to refer to a “phantom plant.” The recent construction of several plant facilities and acquisitions had already pushed Cummins’s debt to capital ratio to nearly 50 percent, well over the company’s historical average of around 35 percent. With the oversupply of inventory, Cummins risked a debt to capital ratio of over 50 percent, which would damage the company’s leverage and threaten continued growth in sales.\textsuperscript{271} Cummins’s philosophy of accumulating inventory to more immediately meet the demands of its customers had apparently led to the “high-bay” design for the Walesboro plant, which was configured so that parts and components could be stockpiled from the floor to the very high ceilings.\textsuperscript{272}

To cut production costs, Cummins began shifting manufacturing to non-union sites in the southern United States. Its Rocky Mount, North Carolina plant, designed by

\textsuperscript{270} Cruikshank and Sicilia, \textit{The Engine that Could}, 413.
\textsuperscript{271} Ibid., 283.
\textsuperscript{272} Ibid., 285-286.
Caudill Rowlett Scott, opened in 1982 [Fig. 2.67]. By 1988 the Walesboro plant was shuttered. The following year, in the first known instance of “greenmail,” the Miller family paid 72 million dollars—5 million over the going rate—to ward off a takeover by British investor Hanson.

Cummins was able to return to profitability in large part due to the fact that its machine shop employees belonged to the Diesel Workers Union, an independent labor organization with no national ties, and therefore less bargaining leverage. Because of this arrangement, Cummins lost little in terms of when it closed plants and laid off workers to cut production costs, and when it reopened the Walesboro plant in 1992 it was able to negotiate starting salaries less than half that of more senior manufacturing workers [Fig. 2.68].

In preparation for the Walesboro plant’s reopening, Cummins carried out a survey of environmental information from prior employees to determine their likes and

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273 The factory was for Consolidated Diesel Co., a joint venture of Cummins and J.I. Case Co.
274 Sarah Bartlett, “Family Pays $72 Million to Defend a Company,” The New York Times (July 18, 1989): A1, D7: “It became increasingly apparent to us, even before Hanson, that the company’s natural long-term needs are out of synch with the short-term nature of today’s shareholder base,” Mr. Miller said. He recalled that when he first joined the board of A.T.&T. in 1959, 85 percent of its stockholders were individuals and only 15 percent were large institutions. When he left the board 21 years later, those percentages had reversed.”
275 Jacqueline S. Gold, “The Twelve Labors: To Hell and Back with Henry Schacht of Cummins Engine,” Financial World 161, 12 (Jun 9, 1992), 60. Cummins chairman and CEO Schacht is quoted as saying: “We’ve had a 60% reduction in costs per person here at Cummins. But $7.50 an hour is not a lot of purchasing power. We pay far less for shop floor work than we did 10 years ago. And if you look at that writ large over the U.S. economy, it has a dampening effect on what otherwise might be a more robust recovery.”
dislikes. This internal effort to appease the labor force was contradicted by later reports that the company had repeatedly violated international labor standards in its treatment of workers and its undermining of labor unions since at least the early 1990s. By the early years of the following decade Cummins was accused of “greenwashing” in its self-promotion to groups dedicated to socially responsible investment while it made extensive contributions to the political action committees of American politicians with records of voting against environmental protection measures. Cummins claimed that its internal codes of ethics and environmental measures demonstrated its dedication to labor and environment issues, obviating any need to adhere to international standards.

In the 1960s, as Cummins had expanded into the European market, its Darlington plant employed material precision in the technical perfection of an exported façade

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279 “Shareholder Proposal Regarding Adoption of International Labor Organization Standards (Item 12 on the Proxy Card)” contained in the Proxy Statement for the Annual Meeting of Shareholders of Cummins Inc. (the "Company") to be held on Tuesday, May 13, 2008,” accessed Feb. 25, 2017. https://www.sec.gov/Archives/edgar/data/26172/000104746908004789/a2184779zdefa14ahr.htm. In 2008 Cummins shareholders filed a proposal with the SEC demanding that the company adopt international labor organization standards that classify the guaranteed right for employees to join trade unions and to bargain collectively as a human right. Cummins countered that it formulated its own Business Code of Ethics and internally certifies that employees adhere to codes of conduct. In effect the company claims to address ethics issues and labor standards internally, rather than submit to international standards. Critics argued these internal codes merely adhered to local law and did not guarantee the right to organize.
composition to demonstrate the company ethos of design excellence, which extended to all scales of activity, from company graphics, to the engines themselves, to workspaces, to the communities within which Cummins operated. Subsequent buildings completed in Europe during the early 1980s, such as the headquarters for Cummins subsidiary Fleetguard in Brittany designed by Richard Rogers & Partners, or the Scottish facility by architects Ahrends Burton & Koralex, adopted the language of high technology by emphasizing exposed structure and externally legible service zones [Fig. 2.69-2.70].

This kind of design approach might be understood as the externalizing of precision.

At Walesboro in the 1970s, and again in the 1990s, a different kind of precision emerged. While the manufacturing processes within this subassembly plant purportedly carried out the Cummins tradition scrutinizing the finest details of engine composition, the environment constructed by KRJDA demonstrated a shift towards precision in environmental containment. Materially constituted, this environmental precision, reflected in the thinness of the building’s membranes and their flawless silicone seams, had reverberating spatial consequences: from the seam to the window to the wall; from the factory environment to the landscape to the city; from the individual worker to the company community to society at large. Cummins, together with Roche and Dinkeloo,

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280 On the Richard Rogers & Partners building see Annette LeCuyer, “Cummins Builds in Brittany,” *Architecture* (June 1984), 69. The European headquarters for Fleetguard, a subsidiary of Cummins that produced heavy-duty engine filters, was constructed in the town of Quimper in Brittany, France. The low-slung shed building was suspended from red-painted external structural masts, which were apparently intended to “convey Fleetguard’s optimism about its manufacturing future as well as the company’s commitment to provide an above-average working environment for its staff.” On the Cummins facility in Scotland see Annette LeCuyer, “Cummins Expands in Scotland,” *Architecture* (June 1984), 72-73. That building was distinguished by exposed steel castellated beams and angular three-storey spines to house the service zones of the building.
developed an internal world that was presented as a proving ground for strategies of energy efficiency and environmental protection, as well as the corporation’s policies on the social organization of the labor force. Compared to the Darlington project, the Walesboro factory bridged between an image-based, representational treatment of architecture towards a more operational, managerial approach. This model of containment reflected a shift in the corporation’s conception of productive workspace, as well as its relation to the wider world. The environmental tactics enacted within the Walesboro plant presented an advantageous symbol of the philanthropic agenda that Cummins advanced, even as the company’s domestic and global commercial dealings complicated and undermined that progressive image.
Chapter 3: Nothing but Glass, Glue, and Conditioned Air: Precision and Emptiness at the Willis Faber & Dumas Headquarters, 1971-1975

Describing the design objectives behind the Ipswich office building for British insurance company Willis Faber & Dumas, completed by Foster Associates architects in 1975, partner Norman Foster detailed the London-based office’s typical working mode of operating as management consultants on projects, transferring responsibility for material fabrication to industry, using prefabricated components to speed assembly on site, and relying upon full scale mock-ups and tests to guarantee building performance [Fig. 3.1]. As an instantiation of the practice’s working method, Foster offered the suspended tinted glass curtain wall enveloping the building’s curved profile, explaining that the streamlining of design with construction management in the development of the façade “made creative aims technically feasible.”

Deriving from the idea that exterior views generate a happy workforce, the all-glass sheath enclosing the building was intended to maximize visual contact with the outside world, but the extensive glazing presented numerous technical problems, including acoustic and solar control as well as challenges relating to its assembly [Fig. 3.2]. According to Foster, the idea of hanging the façade from the building’s roof was prompted by the architects’ recognition of glass’s superior tensile strength, but initially they were unsuccessful in convincing consultants of the strategy’s workability, and early schemes showed the glass façade supported by more conventional steel truss mullions: “Eventually enough calculations and technical details emerged to convince specialist

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suppliers and sub-contractors that the idea was not only viable but also looked very attractive cost-wise (hardly surprising since it reduced elements down to just glass and glue)" [Fig. 3.3].

The final 310m x 16m glazed wall was designed by the Technical Advisory Service of Pilkington Brothers, Ltd. under direct contract with Willis, Faber & Dumas. It was composed of 900 2m-wide panels of 12mm-thick Pilkington “Armourplate Antisun Bronze” body tinted toughened glass with varying heights, and 448 2-meter-high supporting fins of 19mm toughened Pilkington Armourplate float glass hung from the floor above. These were held in place by aluminum and steel clamping strips and patch fittings of brass and black-stoved acrylic, and hung from bolted steel suspension plates. An exposed seam of translucent silicone by Imperial Chemical Industries (I.C.I) sealed the glass plates together [Fig. 3.4]. A flap of extruded neoprene ran along the edges of the concrete floor slabs, against the suspended glass wall, to provide a smoke seal at each floor level. All glass, patch fittings, and suspension fittings were supplied by Pilkington, and Modern Art Glass Co., Ltd. supplied all other components and installed the total system using a pneumatic lift [Fig. 3.5-3.6].

Presenting the design process as the reconciliation of objective limitations with subjective aims, Foster claimed that his practice sought to inject pleasure into the compiling of technical research, cost projections, statistics, etc., an approach that might be understood as pursuing an aesthetics of the quantitative, a way of framing architecture

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282 Ibid. Early interior perspective drawings showed the initial scheme of vertical steel mullions which was prototyped on the Foster Associates building for Modern Art Glass in Thamesmead, London.
that emphasized precision in terms of both performance and representation.\footnote{Ibid. “…the design approach philosophy could be expressed as a process which resolves and integrates those views and polarities which might otherwise be in conflict. For example, the company versus the community; public versus private; new versus old; time/cost versus quality/innovation; socially acceptable versus commercially viable. Another part of the approach is a conscious and deliberate attempt to put all those dry objective pieces of the jigsaw (research, statistics, cost plan, site analysis, structural option—the check list is endless) together with some very subjective joy. It certainly doesn’t cost any more, so why not?”} The paring down of the Willis Faber & Dumas building façade to two elements—just glass and glue—was the materialization of this aesthetic pursuit.

In his treatise on “Late-Modernism,” Charles Jencks used the pared down skin of the Willis Faber & Dumas building to illustrate the signal characteristic of “Slick Skin/Op Effects” [Fig. 3.7]:

As the curtain wall continues to evolve towards ‘less and less’ (mullion) it approaches the ideal condition of a membrane, a surface that can flow easily around corners and over rooftops as if it were skin, or at least inflatable plastic. This diminishes the role of the four facades and the frontality inherent in most buildings. It tends to isolate the building as a free-standing sculpture and do away with all scaling devices—even the mullion disappears in the pure glass skin building. Furthermore it decreases the mass and weight while enhancing the volume and contour—the difference between a brick and a balloon.”\footnote{Charles Jencks, The New Moderns: from Late to Neo-Modernism (London: Academy Editions, 1990), 85. Jencks continues, “In England Norman Foster has pushed the technology furthest with his ‘Big Black Piano’ in Ipswich. The partially reflective black glass moves around the existing site-lines with a kidney or piano shape. From some angles the building reflects the environment, from others it is transparent and, depending on the light, opaque and translucent. Thus four visual conditions are provided with the same material with the added quality of sfumato—the gentle merging of one condition into the next,” Ibid.}

Jencks also used the Willis Faber & Dumas building to represent Late-Modernism’s “isotropic space,” an endless, extreme iteration of the modern universal gridded free plan. He included a photograph of an empty floor-plate of the building with its recessed plenum, expansive green carpeting, and floor-to-ceiling glass hung a meter outside the
column line, a thin transparent shell enveloping an extensive and uniform interior zone 
[Fig. 3.8]: “Ethereal open space flows between a green ground (with its electrical outlets) 
and a baffled ceiling (with its mechanical and lighting grid)…The wall disappears (or at 
least only thin glass fins remain as structure).” 286 In combination with the slick skin, 
isotropic space—which provided maximum habitable area for the least cost—was a 
technique for maximizing commercial gains in real estate development. 287

Fredric Jameson invoked Jencks’s formulation of Late-Modern formalism to 
thorize the relationship between an increasingly abstract global financial system and its 
archetorical corollary. 288 He claimed that Jencks’s “isotropic space” and “enclosed skin 
volumes” demonstrated exactly how the exponential implementation of modernism’s 
modalities resulted in a new postmodern space that operated as an agent of both real 
estate speculation and finance capital:

What it would be important to develop is that both of these principles—
features of the modern which are then projected into whole new and 
original spatial words in their own right—no longer operate according to

286 Ibid., 81.
287 Confessing to being compelled by this typology’s “rigorous aesthetic” and “elegance,” 
Jencks argued that the glassy but obscure reflective skins of Foster’s “darkened 
buildings” were “suitable as ‘decorated sheds…diagrams of sugar-coated real estate, the 
ultimate signs of undiluted capitalism and land value. Jencks compared reflective glass 
facades to “the one-way mirror where technocrats look out at us and coolly plan our 
future, or the mirror-plated sunglasses which hide the gaze of the policeman, but reflect 
yours—all potent symbols of control, even the system of state power.” He continued, “Is 
it a mistake that the Nazis wore black shirts and produced a consistent style of shiny 
black to be used on cars, flags and all objects of control? Foster's darkened buildings 
recall these associations and in the cases such as IBM become the most compelling and 
suitable symbols we have yet invented.” Charles Jencks, "Reflections on Mirrors," in 
288 Fredric Jameson, “The Brick and the Balloon: Architecture, Idealism and Land 
in production to speculation on the stock market, the globalization of finance, and—what 
concerns us especially here—the new level of a frenzied engagement with real estate 
values, these are realities with consequences for social life today…” Ibid., 32.
the older modern binary oppositions. Weight or embodiment along with its progressive attenuation no longer posits the non-body or the spirit as an opposite; in the same way, where the free plan posited an older bourgeois space to be cancelled, the infinite new isometric kind cancels nothing, but simply develops under its own momentum like a new dimension.289

This was a contention that modern dualities no longer applied to the material and spatial conditions of postmodernism, which, rather than contradicting an alternative order—such as balloon versus brick, or weightlessness versus solidity—, offered a kind of pervasive emptiness. The postmodern bubble or balloon, with its thin slick skin and extensive interior, is no longer an abstraction of anything at all.290

Jameson had previously given a more concrete reading of postmodern architecture’s material ramifications, describing Skidmore, Owings and Merrill’s Wells Fargo Court building in downtown Los Angeles as “a surface which seems to be unsupported by any volume,” a “great sheet of windows, with its gravity-defying two-dimensionality…”291 This superficial flatness he linked to the problem of representation in a postmodern culture whose technologies lacked the dynamic force of modernism’s trains and turbines; by contrast, the computer’s “outer shell has no emblematic or visual power,” and the television “articulates nothing but rather implodes, carrying its

289 Ibid., 44. According to Jameson the proliferation of urban skyscrapers in the latter part of the 20th century contradicted the typology’s initial formal intent; rather than disrupting the order of the city introducing a novel spatial condition, through their multiplicity skyscrapers began to generate “a new conception of the enclave, within the city but apart from it, now reproducing something of the complexity of the city on a smaller scale.” Ibid., 38.
290 Jameson describes postmodern nostalgia as “a longing for the situation in which the process of abstraction might itself return once again to be possible, whence the feeling that the newer moment is a return to realism—plots, agreeable buildings, decoration, melodies, and so on—when in fact it is only a reply of the empty stereotypes of all those things…” Ibid., 46.
flattened image surface within itself.” The empty flatness of the glass envelope on the Wells Fargo building or on John Portman’s Bonaventure Hotel, also in Los Angeles, destabilized the relationship between building and urban context, producing fragmented, distorted reflections of the surroundings and obfuscating the hollow interior realm. Jameson depicted the Bonaventure’s interior atrium as an empty stage for frenetic activity to distract and disorient the individual from any understanding of his or her location in space.

If Jameson’s postmodern emptiness described both a lack of abstraction and the staging of a messy “postmodern hyperspace” that precluded any “cognitive mapping” of one’s position in space, the Willis Faber & Dumas building produced another kind of emptiness, though equally postmodern. There, the shell of glass and glue contained an atmospherically controlled interior designed to optimize productivity through a new spatial typology of commodious workspace.

Foster argued that the deep floor plates of the three-storey building, which completely filled the limits of its site, stretching to meet the outlines of surrounding streets, offered more efficient space planning as well as lower overall energy

292 Ibid., 37.
293 Ibid., 42. “...the glass skin repels the city outside, a repulsion for which we have analogies in those reflector sunglasses which make it impossible for your interlocutor to see your own eyes and thereby achieve a certain regressively toward and power over the Other. In a similar way, the glass skin achieves a peculiar and placeless dissociation of the Bonaventure from its neighborhood: it is not even an exterior, inasmuch as when you seek to look at the hotel’s outer walls you cannot see the hotel itself but only the distorted images of everything that surrounds it.”
294 Ibid., 43. Hanging streamers indeed suffuse this empty space in such a way as to distract systematically and deliberately from whatever form it might be supposed to have, while a constant busyness gives the feeling that emptiness us here absolutely packed, that it is an element within which you yourself are immersed, without any of that distance that formerly enabled the perception of perspective or volume.”
295 Ibid., 44-54.
consumption due to the reduced ratio of perimeter glass to floor area compared to a
typical shallow office floor plate. This minimized interface with the unpredictable
weather outside, and a greater reliance on artificial environmental controls, provided
more accurate environmental management, and the deep space—with a large floor area to
façade area ratio—provided organizational flexibility. According to the architects these
extensive floor plates not only forced a breakdown of conventional hierarchical roles, as
workspaces were arrayed in landscape rather than cellular formation, with minimal
separations between spaces, but also addressed workers’ need for leisure and social
interaction. The fully air-conditioned interior—replete with potted plants, a lawn of green
carpet, a swimming pool, and a rooftop restaurant and garden—created a bubble that
workers should never want nor need to leave. This enclosure, divested of any relation to
its urban context, instead reproduced the social functions of the city (park, café, gym,
etc.) within its confines, much like the miniaturized enclave that Jameson described.296
This was presented as a progressive model of workspace, and Foster Associates
commissioned the Evening Standard cartoonist Frank Dickens to produce a series of
cartoons featuring his Bristow character that would illustrate the contrast between this
working environment—flexible, comfortable, efficient, and anti-hierarchical—and a
conventional office in the City of London [Fig. 3.9].

At once an undulating mirror perplexing reflections of the surroundings and a
tight demarcator of a deep interior intended as a prototypical workspace environment, the

296 Ibid., 40. “I believe that, with a certain number of other characteristic postmodern
buildings, such as the Beaubourg in Paris or the Eaton Centre in Toronto, the
Bonaventure aspires to being a total space, a complete world, a kind of miniature city; to
this new total space, meanwhile, corresponds a new collective practice, a new mode in
which individuals move and congregate, something like the practice of a new and
historically original kind of hyper crowd.”
supple glass skin of the Willis Faber Dumas building was doubly legible. With an exterior as illegible as a computer’s casing, and arguably designed with similar aesthetic aims—a package designed to stimulate desire while also concealing its contents—the building’s minimized techniques of assembly positioned architecture as both empty bubble and sculptural object. It was precisely the reduction or disappearance of material components that generated this particular spatial and environmental paradigm: precision produced emptiness.

This interior void supported the operations of insurance and reinsurance brokerage providers distinguished for its unusually international reach. Originally founded in 1828 as Willis & Co., the company merged with Faber Brothers in 1898 to form Willis Faber, and in 1928 merged with Dumas & Wylie to form Willis, Faber & Dumas. The company had a history of providing insurance coverage to ambitious and sometimes politically fraught technical endeavors worldwide. It was the insurance broker for the Titanic; the reinsurance broker for the Hindenburg, the German Zeppelin that exploded in 1937; and the insurance broker for the Lunar Roving Vehicle nicknamed the “Moon Buggy.”

If this interior, which was defined by open and flexible spatial organization with integrated systems of environmental modulation, functioned as one of many technologies supporting global risk management, how were the material techniques of its construction and environmental management systems implicated in the production

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297 British insurance companies are characteristically international operations compared to those based in the United States, Japan, or Germany. Stephen Valdez, *An Introduction to Western Financial Markets* (Basingstoke, Hampshire: Macmillan, 1993), 256.

298 Willis also brokered the insurance to underwrite the reconstruction of the World Trade Center after the attacks of September 11, 2001.
of its internally and externally resonant emptiness? What, exactly, were the technical
criteria for the making of nothing?

Glass, Glue, Thin Skin, and Deep Space

Norman Foster weighed in on the relationship between a discernable “jewel-like
perfection” in his practice’s work and their ongoing efforts to refine internal building
systems: "The things that tend to work well—like good artificial lighting—are 'invisible';
and an immense amount of research into acoustics, energy saving, environmental
systems, flexibility—is often taken for granted." Here again Foster admitted a fixation
with the quantitative aspects of building, which, while often immaterial or invisible, he
insisted should be understood as the basis for any outward image of perfection.

The research into techniques of design, fabrication, and systems management that
the Foster Associates practice had pursued since its inception formed the framework for
the spatial and environmental paradigm offered up at Willis Faber Dumas, as well as the
very specific material assemblies used. The first commission the office received was an
Amenity Centre for Fred Olsen, a Norwegian shipping concern, located in East London’s
Millwall docks. The fully glazed walls at the two open ends of the two-story building,

300 Alistair Best. “Just Arrived in Port: A New Deal for the Dockers,” Design 257 (1970): 23-26. Fred Olsen established itself in the UK in 1963. When it outgrew its Canary Wharf facilities in 1965 it moved further down the eastward flowing River Thames to the Millwall docks. The tonnage handled by the company increased up to 100% annually, and reached 350,000 tons by 1969. Using a system known as "unit loading," in which goods are stacked onto pallets and fork-lifted into a ship's cargo space through an opening on its side with the aid of specially designed Hyster side shifter trucks, Fred Olsen’s workers were better protected from the elements than in traditional loading methods, which also meant that weather did not forestall their operations.
which was completed in 1969, exposed open plan ‘landscaped’ offices upstairs which accommodated general management as well as operational controls for ship movements, labor, and cargo; downstairs were the canteen, recreation spaces, and locker rooms for dockworkers. The architects presented the integration of office staff with dockworkers as a progressive design move, and they suggested the building’s close proximity to the docks would save time for dockworkers on breaks, as, though of course these spatial conditions also maximized dockworkers’ working hours and enabled greater supervision of their leisure spaces [Fig. 3.10-3.12].

The entire Amenity Centre was designed and constructed within a span of twelve months, such speed made possible by the implementation of a management contract—a rarity at the time—as well as component assembly.\(^{301}\) The cover of the September 1975 issue of *A+U*, which was dedicated to the work of Foster Associates, featured the architects’ installation instruction diagrams for the building’s glazing system, a trio of perspectival sketches demonstrating the alignment, insertion, and finishing of neoprene gaskets within a metal framing system [Fig. 3.13]. The use of these diagrams as a cover image seemed to suggest that isolated techniques of assembly were more descriptive of the Foster Associates practice than any portrait of a building in its entirety.\(^{302}\) Foster’s fixation on accelerated fabrication dated back to the period when he was a student at Yale with Richard and Sue Rogers, prior to their formation of the Team 4 office, when they visited American projects such as Craig Ellwood’s Xerox building and Ezra


Ehrenkrantz’s SCSD schools in California [Fig. 3.14-3.15]. Indeed, Team 4’s final project together, the Reliance Controls electronics factory in Swindon, UK, completed in 1967, was quickly erected using prefabricated metal components, and widely acknowledged to be inspired by such American precedents. The Fred Olsen building was based upon a similar logic, but the architects developed the aluminum and neoprene glass retention system in close collaboration with Pittsburgh Plate Glass (PPG). American companies including PPG and Libbey-Owens-Ford (LOF) offered the most advanced techniques in rapidly installed glazing systems at the time, due to their work on a number of extensively glazed buildings, which proliferated in the United States. Though neoprene had been implemented as a construction material in England before (notably in KRJDA’s Cummins Engine Company building at Darlington), the Fred Olsen Amenity Centre’s walls of high performance heat- and light-reflecting LHR Solargray glass by PPG were the first of their kind in Britain. The building stood out amid the blank corrugated metal walls of the adjacent sheds, its mirrored glazing—which reflected the cranes and machinery of the industrial site—transplanted from the “rich executive pastures of Manhattan and Chicago” to the stark London docks [Fig. 3.16].

The environmental performance of this prototypical workspace was widely commended. A+U praised the high environmental standards created by the building’s glare-free lighting system and completely air-conditioned interior; its sole HVAC system was almost entirely contained within the building’s limits, with only compressors and

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303 See Educational Facilities Laboratories, SCSD: The Project and the Schools, a Report from Educational Facilities Laboratories (New York, 1967). Educational Facilities Laboratories is a nonprofit corporation established by the Ford Foundation to support research into physical aspects of educational facilities in the United States and Canada.


305 Best, “Just Arrived in Port,” 29.
vents penetrating the roof [Fig. 3.17].\textsuperscript{306} The light- and heat-reflecting glass obviated the need for any shading or venetian blinds, thereby permitting uninterrupted views of the shipping berths beyond, and from the outside mirrored glass generated a rippled impression of the surroundings. At nighttime, the interior spaces and the pipes and ducts of the two open-ended service zones were visible through the illuminated transparent façade. The open-plan office floors were lined in green carpeting, and the amenity level in green rubberized flooring, suggesting a simulated park or garden with ample light and views outside. The precisely composed surface—reduced to glass, neoprene, and steel framing, as demonstrated in the assembly diagrams—worked in conjunction with the open plan of the deep, air-conditioned interior to form a prototypical workspace environment [Fig. 3.18].

Following the completion of the Fred Olsen building, Foster Associates were commissioned in 1970 to design a temporary building for IBM in Cosham, England to accommodate 750 employees and a number of computers while the company established its headquarters in nearby Portsmouth. This project extended the typology that the firm had developed at Fred Olsen, deploying a rapidly assembled thin glass sheath enclosing a deep open-plan interior in the vein of the shed typology [Fig. 3.19-3.20]. In a “Final Concept Report” for the building, which was completed in 1971, Foster Associates outlined their research on alternative structures for the required building area, which was calculated using employee workspace requirements established by IBM’s World Trade Corporation. One- and two-storey patent timber buildings were rejected for their shallow floor plates and natural ventilation through operable windows, which was expected to

cause noise disturbance from nearby motorway traffic. The architects also argued that this type of building “would not reflect a good image (visually or environmentally) for IBM relocating in a new area.” Prefabricated patent glazing of the kind used in 19th century greenhouses (and in James Stirling’s Leicester Engineering Faculty, completed in 1963) was also rejected for predicted corrosion of aluminum framing members due to the site’s sea air; in addition, the joints between panels admitted draughts, and the 2-foot spacing of mullions would disrupt exterior views. Galvanized steel British Standard sections, configured into a horizontal rectangular framing pattern, were also dismissed for disrupting outside views as well as maintenance concerns [Fig. 3.21-3.22]. The architects also considered a pneumatic structure of the type they constructed for temporary offices to house Computer Technology Limited, but they were deterred by inevitable protracted Building Regulations negotiations, as well as the belief that an air structure would not present an appropriate face for IBM’s future Head Office at the same site.

Instead, the architects developed a custom-designed single-storey deep-plan building with an 18,000-square-foot glazed envelope composed of 4.5-inch Pittco 'T' wall anodized aluminum box-section glazing frames holding 12-foot-high single-glazed panels of 10mm-thick Pilkington Spectrafloat glass, sealed with black neoprene gaskets and secured to a flat steel capping strip at the concealed roof edge. Studies of maximum area glazing panels using ¼ inch glass led to two configurations: one with two rows of

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307 “Pilot Head Office at Cosham,” 2.0. IBM United Kingdom, Ltd., Final Concept Report, Foster Associates." F+P Archives, Box 0785, ID 32023. The report is undated but was issued sometime between March 1970, when IBM approached Foster Associates, and September 1970, when construction was projected to begin.

308 Foster Associates, “Pilot Head Office at Cosham, IBM United Kingdom, Ltd., Final Concept Report,” 2.0-4.0. F+P Archives, Box 0785, ID 32023.

309 1 Maintenance Manual, Cosham, Northern Road, IBM, Foster Associates. F+P Archives, Box 0785, ID 32020.
horizontally placed panels, and one with repeated columns of single vertical panes running the height of the building. The horizontal option was discarded because mullions had to increase in size to support glass load. By contrast, the preferred vertical option would maximize outside views by minimizing mullion size, and the corrosion-free neoprene glazing would reduce maintenance [Fig. 3.23-3.24].

IBM Cosham’s fully air-conditioned 11,000-square-meter interior had two internal service cores. While the perimeter of the building was glazed, there were no interior court spaces and some workstations were positioned as much as 30 meters from a window [Fig. 3.25]. There was no possibility for natural ventilation through its sealed glass skin. Mechanical engineer Loren Butt, who joined Foster Associates in 1970 to work on the mechanical system for IBM Cosham, defended the sealed and fully automated interior environment as simply pragmatic for a building designed to house large computers that required constant air-conditioning [Fig. 3.26]. In response to critics who decried air-conditioned interior environments as wasteful and out of step with the era’s energy crisis, Reyner Banham used the Cosham building as an example to maintain the accuracy and efficiency of “tight fit”—closed and controlled environmental systems—over Long Life/Loose Fit/Low Energy (LL/LF/LE), a principle of permanence and energy conservation in building.

310 “Pilot Head Office at Cosham,” A5-A6.
312 Reyner Banham, "LL/LF/LE vs Foster," Architecture and Urbanism: A+U 57 (Sept. 1975), 55. “That was specifically a temporary facility, tightly fitted round the client’s functional needs, and consuming quite a lot of energy (chiefly because it is virtually impossible to run computers except in air-conditioned environments, and Fosters were
At IBM Cosham the architects also refined their ‘fast track’ working method, in which a “network sequencing” of design and construction replaces a conventional linear sequencing in order to accelerate the overall project schedule. The use of prefabricated components allowed for rapid decision making regarding the building’s overall organization, and detail design was then carried out after construction had begun. The architects argued that this approach to building was not only economical, but that it produced an inherently flexible composition, so that changes could continue to be made following construction completion and even after the client’s occupation of the building.\textsuperscript{313} Fast track development depended upon the architects’ conception of a “synthesis of systems,” in which a building was devised to accommodate prefabricated components from various manufacturers. Air-conditioning, power, and telephone systems were incorporated within modules of an open-framed ceiling zone, and computer wiring was contained within a raised floor. Performance and cost standards were applied and updated throughout the design process.\textsuperscript{314}

The notion of systematized fabrication using pre-formed components was prevalent in the architecture discourse of the period. Rationalized site assembly and precise setting out methods were detailed in journals, and one 1967 article on “Accuracy in Building” highlighted the economy of joints: “The more accurate the components, the smaller the joint needs to be; and the smaller the joint (contrary to common belief) the capitalising on this fact to economise on structure).” In contrast to buildings with heavy brick walls, which may conserve heat, Banham argues that “IBM has a closed and controlled air-conditioning system that knows, pretty accurately, where all the heat is going.”\textsuperscript{313} “Foster Associates,” \textit{Architecture and Urbanism: A+U} 57 (Sept. 1975), 75. \textsuperscript{314} Foster Associates, “Pilot Head Office at Cosham, IBM United Kingdom, Ltd., Final Concept Report,” 2.0-4.0. F+P Archives, Box 0785, ID 32023.
cheaper will be the whole operation of building.”\textsuperscript{315} Accuracy not only reduced material waste but also refined one of the most costly elements of building: the joint. Smooth, reductive constructions were therefore emblematic of technical prowess \textit{and} fiscal savviness, outwardly brazen and inwardly austere. Reyner Banham presented the material assembly at IBM Cosham as a spectacle of minimalism, describing the project as treading the “frontier between technology and envy,” its glass walls "held in place by almost nothing; just aluminium glazing bars about an inch wide."\textsuperscript{316} Architect and critic Robert Maxwell explained that the interior environment at IBM Cosham sought atmospheric comfort through “a delicate balance of the physical factors, and a minimum of physical means,” going on to observe that “the glass is seen to stretch all the way from the damp-proof membrane on the ground slab to the damp-proof membrane on the roof. There is nothing intellectually but a gestural plane.”\textsuperscript{317} According to Maxwell, the Foster Associates design method treated architecture as only one aspect in a comprehensive business strategy; as a physical artifact, a building functioned less as permanent operational home than as an outwardly visible symbol of the brand:

> In a capitalist economy, the conventions of industrial design consider aesthetic surface as no less important than functional and economic efficiency. By treating architecture as industrial design Foster legitimizes his search for aesthetic excellence along with technical competence. Architecture is reduced to a client-directed package, but the package

\textsuperscript{316} Reyner Banham, "LL/LF/LE vs Foster," \textit{Architecture and Urbanism: A+U 57} (Sept. 1975), 53.  
includes architecture.”

The stark container of empty space at IBM Cosham could thus be read as simultaneously accentuating and evanescing the architectural surface [Fig. 3.27]. As such, the building’s minimalist envelope constituted both a flexible vessel for evolving corporate growth, and an identifiable figure symbolizing IBM’s technical currency.

**Prototypes, Constraints, and Obstacles**

Foster Associates’ continued endeavor to reduce the membrane of enclosure by eliminating superfluous components was driven by the desire for a smooth, unarticulated surface with the capacity to mirror the technology-based market power of their corporate clients. The techniques the architects used to formulate such an envelope, and their collaborations with manufacturers, positioned their work as tantamount to packaging or industrial design, but at the scale of a building rather than a computer or a car.

The September 1975 issue of *Architectural Review* included a full-spread advertisement by Pilkington Glass, in which they boasted of their role in producing the world’s largest suspended glass façade at the Willis Faber & Dumas headquarters building, a “£5½ million 'gleaming grand piano of solar control glass'.” For the first time Pilkington had accepted complete design responsibility for a facade, and the glass envelope they designed was an extension of the Pilkington Suspended Assembly system, whose advantages included a maximum height over double that of other all-glass façade systems and the capacity to withstand extreme winds and temperature fluctuations. In addition, the 900 glass plates in the building’s frameless, mullion-free façade were

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318 Ibid., 57.
produced using a standard module, with a system of theoretical datum points for glass installation that enabled glass production to continue even during the construction process [Fig. 3.28].\textsuperscript{319} The suspended glazed wall at Willis Faber & Dumas was the product of proprietary research and design knowledge by glass manufacturer Pilkington Brothers, Ltd.; glass assembly design by subcontractor James Clarke & Eaton, Ltd.; glass assembly component supply and installation by Modern Art Glass Co., Ltd.; glass support systems engineering by Martin Francis; and sealant manufacture by Imperial Chemical Industries (I.C.I.).

To develop their vision of a dematerialized transparent building with an all-glass skin uninterrupted by framework or mullions, Foster Associates had implemented the Total Vision System (TVS) by PPG for the 15m x 3m shop-front window of their Fitzroy Street office in London; this was an all-glass system glued with a silicone sealant, with annealed glass fins for support. While they had initially planned to use the same system for Willis Faber & Dumas, they realized that the building’s tapered concrete floor slabs were an unsuitable surface upon which to affix a multistory glass façade encircling a curvilinear perimeter. The slender 6-inch-thick slab edges were dimensionally unstable and were expected to move, and it was therefore unsafe to attach a rigid, inflexible glazing system to the building’s floor slabs, as was the convention for curtain wall systems.\textsuperscript{320} The architects were therefore tasked with developing a new glass façade system using minimal structure, and they researched a number of all-glued glazing systems, including the SHG building in Detroit by Smith Hinchman Grylls and a

\textsuperscript{319} “Whatever Made Them Do It?” Pilkington Glass Advertisement, \textit{Architectural Review} (September 1975).
\textsuperscript{320} Martin Francis in discussion with Alexandra Quantrill, October 22, 2013.
suspended system of annealed glass developed by Glasbau Hahn [Fig. 3.29].\textsuperscript{321} One early concept was to use truss mullions to support the glass walls, with sliding joints at each floor level to accommodate movement, though this idea was abandoned in favor of 6-inch chrome-polished tube mullions, to which glass could be affixed using continuous metal clamps covered in rubber and neoprene [Fig. 3.30-3.32].\textsuperscript{322}

The design of the lean glass envelope for Willis Faber & Dumas drew from previous precedents like Fred Olsen and IBM Cosham, but the architects also prototyped an early version of the skin in their building for Modern Art Glass (MAG), who had been the glazing subcontractors on the Fred Olsen and IBM projects.\textsuperscript{323} Based in Leeds, MAG was one of the United Kingdom’s largest privately owned suppliers and importers of glass. The company wished to establish a branch in London on the Thamesmead industrial estate, and it commissioned Foster Associates to design a building encompassing a warehouse, offices, and a showroom. In a showpiece embodying the precise glass construction MAG was known for, Foster Associates erected a 10,000-

\begin{footnotesize}
\begin{enumerate}
\item Ibid. At the SHG building, glass was glued to aluminum extrusions, and star-shaped metal components were added to the outside face of the glass to prevent panes from blowing out. See Thomas J. Holleman and James P. Gallagher, \textit{Smith, Hinchman & Grylls: 125 Years of Architecture and Engineering, 1853-1978} (Detroit: Wayne State University Press, 1978), 175-179. Glasbau Hahn invented suspended glass curtain walls using annealed glass, which could be built up to 10m long, but the glass couldn’t be toughened for strength due to its length. The system was used in a number of projects in Switzerland and France, including Maison de la Radio in Paris by architect Henri Bernard (1953-1963).
\item Ibid. It was determined that a 2-meter span between trusses was the most reasonable to accommodate wind loads of 42 pounds per square foot and a floor-to-floor height of around 4 meters. The architects planned to use Belgian glass contractor Glaverbel for this system, and body-tinted Parello glass, which had a slightly mirrored finish.
\item Describing the design development of the Willis Faber & Dumas façade, Foster explained that “all the interior perspectives of that period show a steel mullion system designed for the project and tested out on a smaller installation in Thamesmead.” See Norman Foster, “Foster Associates: The Design Philosophy of the Willis Faber + Dumas Building in Ipswich”, 614.
\end{enumerate}
\end{footnotesize}
square-foot prefabricated structure comprising six steel portal frame bays clad in aluminum panels, which was completed within six months [Fig. 3.33]. One gable end of the building was composed of 12mm toughened bronze-tinted glass supported on a framework of vertically oriented circle-section tubes for lateral support, with cruciform steel retention plates. This glazed wall served as the prototype for the Willis Faber & Dumas building’s glass envelope and a test bed for the tube mullion concept [Fig. 3.34]. Flanges projected from the mullions to support the glass panels, which were secured down two vertical edges by neoprene mullions bolted with steel; these were placed outside the glazing line and acted as a weather seal. Horizontal glazing joints were sealed with silicone, and a small tongue of metal concealed within the silicone bead supported the weight of the glass [Fig. 3.35-3.36].

In a critique of the project, John Winter contrasted it against a typical postwar English factory, “a sorry tale, with low office buildings tacked to industrial sheds.” Winter cited two exceptions to this inferior standard: the SBI prototype factory units at Milton Keynes by the Industry Group and Derek Walker, completed in 1973, and the Cummins factory at Darlington by Kevin Roche John Dinkeloo Associates (KRJDA), completed in 1966 [Fig. 3.37]. According to Winter, Foster Associates’ Modern Art Glass building, while more linear in orientation, could be compared to the Cummins factory for its configuration of offices at one end of an open shed. The MAG building

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324 J. Manser, “That Up-Stage Blue One,” Design 308 (Aug. 1974), 41-42. Martin Francis, who also worked on the design of the Willis, Faber, & Dumas glass skin was employed as a “component consultant” for the glass wall at MAG.
326 The SBI factory unit prototype was composed of 12m x 12m steel frame bays clad in 1m x 2m plastic-coated steel panels, and was devised for easy modification and expansion.
also exhibited advanced assembly techniques, but Winter claimed it did so for different ends:

…like Cummins it uses metal skillfully and pushes glass detailing to a further stage of development. But Cummins aspires to High Architecture whereas at Modern Art Glass Foster Associates have taken the portal frame and the corrugated covering of the typical factory and refined and upgraded it. So the impression is not ‘what a marvelous work of architecture’ but ‘why can’t all factories be as good as this?’ 327

Winter here distinguished between the material strategies of two factory buildings: the application of sophisticated materials more commonly used for office buildings, and the refinement of industrial materials themselves. That juxtaposition of expensive materials typically designated for corporate buildings with finely detailed but cheap industrial materials became a trademark of the Foster Associates practice, part of a strategy to create minimized component assemblies that could offer a legible symbol of their clients’ commercial dexterity and technical expertise. 328 In effect, this ambidextrous incorporation of both high- and low-end components rendered architecture an exercise in industrial design, in which the materials and techniques used to package the building presented an appearance of sleek flawlessness, an image that depended upon precision in the composition of material elements.

The resolution of the MAG building’s glass curtain wall, with its neoprene- and silicone-jointed glass panels, provided the architects a proving ground for construction

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327 Winter, “Glass on the Marsh,” 57.
328 Foster Associates included the Cummins Darlington building in a pictorial essay showing influences on their work that was included at the back of the Sept. 1975 issue of A+U which was dedicated to the practice’s work. The pictorial essay included a range of other influences such as: the Pierre Chareau house, SOM’s Gunners Mates building, oil rigs, the Vought SA 315B Lama helicopter, the Eames House, Frank Lloyd Wright’s Usonian house, digital watches, Sony TVs, the Crystal Palace, and the Osaka Pavilion.
principals being considered for Willis Faber & Dumas, although this system was ultimately dropped in favor of a fully suspended glass curtain wall. According to Martin Francis, a consultant on both the glass façade for the MAG warehouse and the Willis Faber & Dumas building’s glass skin, affixing a rigid glass system like that used at MAG to a movable concrete structure like that of Willis Faber & Dumas was “totally fraught with risks.” In a reflection of the work that the headquarters building would accommodate, probabilistic analyses of performance and construction sequencing for the glass envelope were used to buttress arguments for the building’s outward form and appearance as well as techniques of fabrication. Francis produced a “Constraints Diagram” which detailed a number of physical risk factors in the design of the glass envelope, including: limits to overall dimensions due to the building’s curved form, manufacture and assembly tolerances, building movement, wind loading, thermal movement, impact, and sonic boom [Fig. 3.38]. This diagram was used as graphic support for adopting a more flexible suspended glass assembly, which the architects argued could best address all the risks presented.

The architects approached Pilkington Glass about adapting the MAG system for a larger-scale building, but it was eventually agreed that they would collaborate on a system using patch fittings. Pilkington had used these on a glass façade for the Centrepoint building in London, in combination with glass fins for lateral support, and

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329 Martin Francis in discussion with Alexandra Quantrill, October 22, 2013.
330 A planning permissions meeting held on November 14, 1972 addressed the risks associated with wind-induced glass movement in a glass retention system of stainless steel trusses with neoprene gaskets. “Various Planning Permissions, Meeting Reports, 1971-1974,” F+P Archives, Box 0006, ID 26905.
sliding connections for flexibility [Fig. 3.39]. While the Centrepoint wall was only one storey high, Pilkington accepted the challenge of adapting the patch fitting system for a multistory structure, propelled by the prospect of being credited for developing the largest suspended glass wall in the world. Pilkington Brothers designed the final glass wall under direct contract with Willis Faber & Dumas, and supplied the glass, patch fittings, and suspension fittings, while Modern Art Glass were responsible for the rest of the components as well as installation.

In collaboration with Foster Associates Pilkington developed a patch fitting with a ball joint rather than a tongue and groove, so the patch could rotate to accommodate the angular variations of a curved wall [Fig. 3.40-3.41]. The 920 panes of the 4,500-square-meter glass skin were hung from a plate bolted to the roofline, each connected to the one above with the patch fitting to form an independent vertical ribbon of glass. Though the patch fittings looked square, each was divided down the center to allow for vertical movement between the ribbons of glass panes. To prevent differential movement, the top of each strip of glass was attached to a horizontal steel supporting bar with five bolts; the center of these bolts attached to the roof structure with a single I-bolt, which held the weight of the entire glass assembly [Fig. 3.42]. While the patch fittings were nominally the mechanical support for the wall, and the silicone between the glass panes was designated as a weather seal, in reality, the silicone also performed structurally. In the event that a single pane of glass shattered, as occurred a week after the building’s opening in June 1975, the silicone transferred the load to the two adjacent vertical glass

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331 Martin Francis in discussion with Alexandra Quantrill, October 22, 2013.
ribbons, so that the ribbon with the broken panel did not actually collapse [Fig. 3.43].

The convention for glass installation was to begin at one point on the building’s perimeter and then continue to glaze the building from there, measuring the resultant gap at the end and cutting extra pieces to close the skin. For the Willis Faber & Dumas building, the architects devised a technique of “setting out” the perimeter, using computers to calculate the dimensions and spacing of glass panels. A tolerance of 50mm or 2 inches, well in excess of typical standards, was specified for perimeter glazing to accommodate the building’s large size and curvilinear form, and any concrete movement due to live load deflections and gradual drying out. The bottom edge of the glass skin passed below the line of the pavement in a gap designed to allow for vertical movement [Fig. 3.44]. To provide a firebreak, a neoprene flap was installed along each floor-plate perimeter to act as a smoke seal that would still allow for continuous movement in the glass skin [Fig. 3.45].

All of this precise detailing amounted to the realization not only of the world’s largest suspended glass facade, but also of a prototypical seamless, shimmering skin, so minimal in its composition that it virtually vanished. The facade capitalized upon the “glassiness of glass” by reducing joints and hardware to a minimum, and each detail—from the patch fittings of the suspended assembly, to the silicone joints, to the internal neoprene firebreak—was constituent of this smooth transparent membrane, suspended quite literally in tension, and stretching around a tightly managed cavity of conditioned

332 Martin Francis in discussion with Alexandra Quantrill, October 22, 2013.
333 See Christopher Woodward, "Head Office, Ipswich, Suffolk," in “Ipswich Reflections,” Architectural Review (September 1975), 149. The article states that the skin was set out by computer but installed using suction pads.
334 Martin Francis in discussion with Alexandra Quantrill, October 22, 2013.
Energy, Production, and a Critical Path

The design and construction of the Willis Faber & Dumas building took place amidst major energy conservation efforts in Britain due to the worldwide energy crisis in 1973. A three-day workweek was implemented, so the Foster Associates staff met in alternate locations to continue their design work, although the energy shortage had a far more significant impact on material production.336 A February 1974 letter from the contracts manager of the Pilkington Flat Glass Division to general contractors Bovis Construction Limited announced a delay in the manufacturing of Armourplate Bronze glass panels.337 Pilkington were scheduled to deliver fifteen shipments of stock glass sheets manufactured using the float process, in which raw materials—including 20% broken glass, locally quarried materials, soda ash supplied by ICI, and sand imported from Belgium—are melted down in a furnace, and the resultant glass is poured onto a bed of 3-inch-thick molten tin. This tin bed lies atop furnace blocks, which are heated using electricity, where the glass solidifies, taking on the finish of molten tin. Following the float process, glass is

335 “Ipswich Reflections,” Architectural Review (September 1975), 131. Here the editors of the Architectural Review argue that the building’s “incidents of the design-- the fixings and the joints-- are minimised to the point of disappearance, it is, of its nature, an eliminator of particularity.” Ibid., 132.
336 Ibid.
337 Letter from M.E. Day, Contracts Manager for Pilkington Flat Glass Division, to Mr. A. Page at Bovis Construction Limited, Feb. 28, 1974. F+P Archives, F22073 Willis Faber Dumas General Correspondence. “Due to technical problems with CH. 1 tank Pilkington will be delayed in producing and delivering Armourplate Bronze glass panels. Contractors must decide whether to wait for panels or to go ahead with construction using untinted 12mm Armourplate panels which would later be replaced with Bronze. Bovis to advise Modern Art Glass of their decision so MAG can order new panels if necessary.”
annealed and cut into standard sheet sizes. The toughening process is carried out on fully formed glass sheets that have been precisely cut, drilled, and ground. It involves heating the glass to a semi-plastic state while suspended in an electrically heated oven, and then rapidly cooling it to induce a permanent stress.\footnote{338}{“Report on the Status of Pilkington Brothers Glass Production for Willis Faber & Dumas Ipswich Centre: (from Pilkington to client).” F+P Archives, F22073 Willis Faber Dumas General Correspondence.}

Bronze glass of the type specified for the Willis Faber & Dumas building was produced twice a year in the Pilkington plant, in batches taking around 14 weeks.\footnote{339}{Ibid. The entire quantity of glass required for the Willis Faber Dumas building could be produced in 14 hours.} In order to begin a run of colored glass, the entire production system had to be purged. This took place following routing maintenance and repair periods, after which the plant had to be very carefully reheated, a process requiring 1.3 megawatts of electricity. The plant would then begin a run of 6mm clear glass for a 2-week period to calibrate the system before moving on to more complex glass configurations of greater thicknesses and different colors.

In December of 1973, the plant at which Pilkington intended to produce the bronze glass to supply the Willis Faber & Dumas project was opened following routine repairs, but it could not be reheated in the normal manner due to the energy crisis. Pilkington delayed reheating until mid-January 1974, and used town gas in place of electricity to heat up the plant because they were unable to secure a generator powerful enough to sustain the heating process. This gas heating apparently diminished control over the float bath, and impurities entered the molten tin through cracks in the furnace blocks, resulting in visible bubbles as well as microscopic black specks and horizontal

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shear cracks, which would induce failure in the toughening process. The entire system had to be shut down and overhauled in February 1974, and was not to reopen until sufficient electric power was available. Glazing originally scheduled to begin production in January 1974 was delayed until May 1974 at the earliest. By February 1974 only 21% of the total perimeter glazing had been produced, and all panels from the second row below the top of the building were missing. Due to the nature of the suspended glass assembly, the only way to proceed with construction so as not to fall behind in scheduling was to substitute clear glass for the missing panels, which would have to be replaced with bronze-tinted panels when they became available [Fig. 3.47].

The various collaborators in the building’s construction consulted closely on the most efficient means of production and assembly through tightly organized schedules. In a May 1971 site and program feasibility study for Willis Faber & Dumas Foster Associates proposed a condensed schedule in which the three phases of building production—brief, design, and build—would be overlapped to reduce the overall time span of the project and, consequently, its budget. Compared to the typical eight-year timeline for office buildings of a similar size, the architects projected that by overlapping phases the building could be completed in a four-year period, with building occupation

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340 Ibid. Pilkington predicted that the cost for the clear glass panels would amount to around 4,000 GBP, plus an unknown additional amount to cover re-glazing with the bronze panels.
341 Apparently an advertisement featuring a photograph of the unfinished building was published before its completion, leading to unfavorable reviews of the building’s appearance. This may have been due to the temporary transparent glazing panels. See Dan Cruickshank, “Willis Faber & Dumas, Ipswich 1975-1997,” RIBA Journal 104, 7 (July 1997), 45.
scheduled for late 1974.\textsuperscript{342} In order to remain on schedule, therefore, they had to accept Pilkington’s suggestion of temporary clear glazing.

Foster Associates had implemented a systems approach to building construction from the first, and had described the IBM Cosham project as ‘a synthesis of systems.’ James Meller, a collaborator in the Foster Associates office who introduced Norman Foster to Buckminster Fuller, edited an issue of Architectural Design dedicated to the systems approach, which, he explained “describes a whole in terms of the relationship of its parts, the interactions of those parts with each other, and in the case of open systems, with their environment.”\textsuperscript{343} In an interview with architects Nicholas Grimshaw and Terry Farrell, Meller discussed the degree to which a systems approach was linked to high technology in architecture.\textsuperscript{344} Both Grimshaw and Farrell dismissed any association, positing instead that so-called ‘low-tech’ and ‘alternative technology’ approaches used systems in similar ways. For Farrell and Grimshaw, the value of systems thinking in architecture was its capacity to make building technologies and materials flexible and open to adaptation by users.\textsuperscript{345} Implicit but unstated in this discussion was the question of how systems thinking affected not only the act of architectural assembly but also the appearance of the product, and Grimshaw and Farrell seemed to be arguing that an aesthetics of the system united their work more than an image of high technology [Fig. 3.48].

\textsuperscript{342} Willis Faber Dumas, Site and Programme Feasibility Study [Foster Associates], May 1971. F+P Archives, R44971.
\textsuperscript{344} Grimshaw and Farrell were associated with the “High-Tech architecture” label, as was the Foster Associates office.
\textsuperscript{345} Ibid., 269-273.
For their part, Foster Associates also resisted any suggestion that their “synthesis of systems” had anything to do with image, and they presented building systems in correlation to the organizational systems used to manage the design and construction processes. During the early 1970s, as the building industry became more specialized, and problems of knowledge transfer and mediation between manufacturers, contractors, and other parties in the construction process became critical, new methods of project management using various principles of computational logic were readily adopted by the construction industry as a means of orchestrating and transitioning between key moments in the building process.

In a schedule appended to their contract estimate glass subcontractor James Clarke & Eaton, Ltd. proposed to “[a]llow for producing 'Programme Evaluation and Review Technique' (PERT) or ‘Critical Path Studies’ or other approved form of network analysis programmes for the Works to be carried out in consultation with Bovis.” The Critical Path Method (CPM), an algorithm for project management, was invented in the mid-1950s by Morgan R. Walker of the DuPont chemical corporation with James E. Kelly, Jr. of Remington Rand Univac as an approach to interrelated steps within a project schedule. A critical path is a sequence of separate and progressively ordered activities on a project’s activity network in which any delay will impact the timely completion of the project. The Program Evaluation and Review Technique (PERT) was developed in the late-1950s by the U.S. Navy’s Special Projects Office, together with aerospace company Lockheed Missile Systems and consultancy firm Booz Allen & Hamilton, as a method of

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management and a prognostic tool for controlling the work of thousands of contractors on
the U.S. Navy’s Polaris missile program.348

This kind of systems or network thinking, forged within the climate of the Cold
War, impacted not only contractors’ construction scheduling, but also a whole approach
to the built environment taken up by architects like Foster Associates. If PERT was a tool
to guarantee timely completion of ballistic missiles in the face of fears over the Soviet
Union’s expanding nuclear arsenal, when adapted to building construction these network
theories became a form of risk management, shoring up a project’s economic and
material efficacy. The ‘synthesis of systems,’ which at IBM Cosham indicated a visible
organizational logic for the building, evolved into a more convoluted means of
coordinating design, fabrication, and component assembly in the face of various
challenges related to cost, energy, and the communication of information. It is therefore
symptomatic of the ways in which network theory penetrated thinking on ecology and the
built environment that American inventor, technophile, and sometime-collaborator of the
Foster Associates practice Buckminster Fuller titled his 1981 magnum opus—a history of
human civilization, natural resources, and global economics—*Critical Path*.

**Outside Awareness**

If charts and diagrams illustrating networked systems enabled the streamlining of
construction schedules and communication between consultants, the material components
within a ‘synthesis of systems’ had unavoidable spatial and environmental implications to

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348 See Booz, Allen & Hamilton, *The Management Implications of PERT* (New York:
Booz, Allen & Hamilton, Inc., 1962), 1-4. PERT dealt only with time constraints, while
CPM also addressed questions of cost and quality.
be resolved and refined. In materializing the external image of a simplified glass wrapping—the architecture of the container—Foster Associates produced unique internal environmental conditions. The interior atmosphere which resulted from a relatively crude membrane construction—reduced down to glass, sealant, and minimal hardware—had to be post-rationalized to validate this thinnest of skins. While this glass-skinned interior volume concerned ideas about productivity and visual experience, it also came to entail a particular approach to environmental management.

During the design process for the IBM Cosham building, Foster Associates applied the company’s concept of “outside awareness” to support the paradigm of a deep, open-plan office building with a fully-glazed perimeter envelope to maximize workers’ connection to the exterior world.\(^{349}\) Even with solar glass panels, however, the single-glazed façade was expected to transmit some solar radiation, and to lose heat in winter, so the peripheral zone could not easily be occupied full-time. A 6-foot-wide open zone for circulation, waiting, and relaxation was maintained around the perimeter of the building, purportedly to strengthen views and maximize the passage of light through external walls, but this peripheral cushion of air operated as a kind of environmental buffer zone, protecting interior workspace from the weather outside \([\text{Fig. 3.49}].\)\(^{350}\) Norman Foster described this space as performing an atmospheric separation from the outside world, even as it provided visual access to the outside: “I think there's continual awareness of the exterior, even in the most remote corners of IBM and as you move about that building you find that the prime circulation route is engineered in such a way that it's anaesthetised


\(^{350}\) “Pilot Head Office at Cosham,” 4.4. IBM United Kingdom, Ltd., Final Concept Report, Foster Associates.” F+P Archives, Box 0785, ID 32023.
space: the chances are it will be too hot to work in, it will have glare— and that's quite a
deliberate contrast." Here Foster justified the configuration on the grounds of
environmental comfort and aesthetic satisfaction: the buffer zone makes the thin glass
skin and deep air-conditioned interior environmentally feasible, and it also creates an
empty gap along the building’s perimeter that enhances the sensation of being held within
a taught transparent glass bubble.

Applied to the Willis Faber & Dumas building, the outside awareness borrowed
from IBM seemed to complicate the tension between the razor-thin hermetically sealed
external surface and the deep-plan interior [Fig. 3.50-3.51]. Foster argued, "The heart of
Willis Faber is more exciting than the perimeter. That's quite an interesting thought
because the traditional and justified criticism of deep-plan offices is that they become
progressively less unacceptable [sic] environmentally the further you are from the
edge." In addition to creating visual relief, Foster claimed that the “large
glazed perimeter-defining circulation routes” had little impact on energy consumption in
such a deep-plan building [Fig. 3.52-3.54]. Foster Associates’ in-house mechanical
ingineer Loren Butt, who had also worked on the IBM building, described the peripheral
circulation spaces at Willis Faber & Dumas as “intermediate thermal zones which reflect
the outdoor weather,” and suggested that “[p]eople enjoy the occasional variation in
conditions they experience when moving from one part of the building to another.”

351 "Questionaire to Norman Foster," 51.
352 Ibid.
353 Norman Foster, “Foster Associates: The Design Philosophy of the Willis Faber
354 Loren Butt, “Mechanical Services Notes; Ipswich Reflections,” *Architectural Review*
(September 1975), 141.
While Butt argued that the deep-plan structure was energy efficient was due to its reduced ratio of interior space to perimeter glazing, the insulation provided by its landscaped roof, and the solar control offered by its tinted glass envelope, he presented the building’s mechanical services concept less in terms of energy efficiency and more for the ways in which it complemented both the building’s form and its internal organization, which was intended to cultivate a contented and thereby productive workforce: “The servicing concepts are essentially simple. They avoid the costly complexity which often results when extreme emphasis is placed on achieving the lowest possible fuel consumption…A stimulating environment leads to efficiency and productive work which leads to energy conservation in its wider sense.”\(^{355}\) Here Butt deftly linked the significant energy consumption of the building’s mechanical services to both immediate cost savings and long-term cost efficiency, not through any technical means but in purely aesthetic terms [Fig. 3.55]. Even the space housing the building’s heavy mechanical equipment—a highly visible glass-walled room on the ground floor with ‘shop window display’ lighting—was carefully designed using models to perfect the layout [Fig. 3.56].\(^{356}\) While he cast the under-conditioned peripheral zone as a refreshing break from a continuously controlled interior atmosphere, Butt presented the building’s internal office spaces as a benign environment, a “good place in which to be,” providing external views and interior amenities like the cafeteria, exercise facilities, and roof garden [Fig. 3.57].\(^{357}\) Omitted from this depiction were the thermal limitations of the building’s single-glazed envelope, which, though tinted for solar control, had no insulating capacity.

\(^{355}\) Ibid.

\(^{356}\) Ibid. A large data processing computer and an electronic telephone exchange, which both operated 24 hours a day, were each given independent air-conditioning systems.

\(^{357}\) Ibid.
Instead, the fully-conditioned interior encompassed by a transparent skin providing uninterrupted views to the city outside was offered up as the realization of the kind of temperate bubble seen in a geodesic dome by Buckminster Fuller: a paradigm of environmental optimization and endlessly adaptable space.

“**The Case for Air-Conditioning**”

The environmental management of white-collar workspace, packaged within newly constructed glass-skinned buildings, was a subject of scientific scrutiny during the period. In a review of Gail Cooper’s *Air-Conditioning America*, a technical and social history of air-conditioning in the first half of the 20th century, Loren Butt expounded the multi-pronged impact of mechanical systems design:

> In any modern building it is the engineering services that represent the largest proportion of the capital cost, and of this air conditioning, when it is applied, tends to be the largest subsection. The impact of air conditioning on building design is all pervasive—form, shape, external envelope performance, internal space planning, and all the energy aspects. It is, therefore, an important subject, worthy of study by anyone interested in the general technology of building construction. One might extend this to include a wider audience, on the basis of CP Snow’s assertion in his famous ‘Two Cultures’ lecture, that thermodynamics is the most appropriate scientific knowledge to be shared by everybody—and thermodynamics is the root science that air conditioning draws upon.\(^{358}\)

Butt was referring to a 1959 lecture by physicist and novelist C.P. Snow, subsequently published as “The Two Cultures and the Scientific Revolution,” in which he argued for greater communication between the arts and sciences to improve worldwide social and

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Believing the arts to have greater bearing in British society than the sciences, Snow advanced a technocratic liberalist ideology, in which educated scientific experts would work for social improvement through established institutions. This position grew from despondency over Britain’s loss of economic might as its imperial reach dwindled in the postwar years, and it influenced British cultural discourse from the 1960s on. Great numbers of architects, engineers, and many others involved in the construction industry assumed this faith in the sciences and technology to rehabilitate British society.

Snow’s argument for the cultural impact of technological development was reflected in the programs of several private- and state-sponsored British building research initiatives. Several government agencies focused on the problem of environmental comfort in office spaces; one of these, the Building Research Station (BRS), tended to focus on the production costs of environmental controls systems, as well as their effects on worker psychology and productivity. A 1966 survey of postwar office buildings in the City of London analyzed occupants’ reports of thermal comfort in various weather conditions, and concluded that summer heat, overheating in winter, and overall “stuffiness” were the greatest problems affecting worker productivity [Fig. 3.58-3.60]. The report claimed that this widespread dissatisfaction with the working environment was a consequence of heavily glazed buildings that privileged day-lighting and outward

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appearance at the expense of control over thermal conditions, concluding that architects’
aesthetic preferences had outweighed technical environmental considerations in the
design of these buildings:

…many of the defects of the contemporary office arise from the pursuit of
objectives, such as obtaining more natural light by increasing fenestration,
in themselves of dubious utility, and of adopting forms of
construction such as the lightweight curtain wall originating in the U.S.A.,
without the use of the double-glazing, air-conditioning and sun-
shading which would seem to be their necessary concomitants. It is
possible that designers have assumed that problems of solar heat gain
could be ignored in Britain. The results of the present survey strongly
suggest that the British climate can frequently produce intolerable thermal
conditions in highly fenestrated, light-clad buildings.”^362

A subsequent study on “The Experimental Office” by the Ministry of Public
Building & Works aimed to respond to such concerns by providing quantitative data and
strategies for environmental management.^363 Completed in 1969, the project was devised
to test interior working conditions in office buildings that combined extensive external
glazing with open “landscape” space planning. A single-storey prototypical office space
was elevated on columns to allow entry from the center of the space as in a multi-storey
building, and the office floor was completely clear except for a service core [Fig. 3.61-
3.62]. To offset solar gain through the extensive double-glazed windows, the roof
projected four feet beyond the window line, and external vertical fins and internal

^362 Ibid., 47.
^363 See “The Environment Ministry,” *Built Environment* 1, 1 (April 1972), 34. In 1970,
under the Conservative government of Harold Macmillan, the Ministry of Public
Building & Works was combined with the Ministries of Housing and Local Government,
Transport, and Public Building to form the Department of the Environment. The 1971
Rothschild Report on “The Organisation and Management of Government R&D”
distinguished between pure and applied scientific research, and suggested that all
government-funded applied research, such as the experimental office at Kew, should be
organized on a customer/contractor basis. Building Research, under the Department of
Environment, already operated under such a model.
venetian blinds reduced glare; these measures apparently reduced peak solar heat gain by 72 percent. The installation of full air-conditioning throughout the interior involved careful consideration of the relationship between artificial lighting, air handling equipment, and integrated structure and services in ceiling and roof zones; altering any of these created new environmental conditions with a new cost distribution. A report on the project emphasized cost as a fundamental parameter: “As the analysis shows, cost implications of open planning are extensive. A sobering aspect of this experiment is the high cost of providing controlled environmental conditions by mechanical means—approaching 50 per cent of the total cost.” During the design development of the Willis Faber & Dumas building Foster Associates cited the experimental office study as a resource for quantitative data on the integration of systems as well as overall cost calculations for fully air-conditioned open-plan office spaces.

There were a number of British publications in the 1960s and early 1970s that detailed the principles behind Bürolandschaft or ‘office landscape,’ an approach to office design using organization theory and social psychology contrived by the German Quickborner Team in the 1950s. These British publications included Francis Duffy’s Office Landscaping: A New Approach to Office Planning, and Alfons Wankum’s Layout

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365 Ibid., 32.
366 Foster Associates Progress Reports 19/12/72-13/2/73. F+P Archives, BOX 0006/ID; 26902. A report on lighting requirements, dated 17 November 1971, names the Fred Olsen Centre and IBM Cosham as projects which gave Foster Associates sufficient experience and knowledge to recommend 1000 lux as the most economical lighting level in relation to air-conditioning costs, and which also avoids glare problems. The report cites as support for this recommendation the data published by the Ministry of the Environment coming from their experimental office project at Kew.
Planning in the Landscaped Office, both published in 1969 [Fig. 3.63]. A typical landscaped office had low ceilings and deep floor plates, which allowed for uninterrupted open-plan arrangements of furniture and equipment. Natural lighting from glazed exterior walls was balanced with artificial lighting at the heart of the building, and due to the deep floor plates mechanical ventilation and air-conditioning were required. Duffy, the United Kingdom’s biggest proponent of the method, argued that landscaped offices offered employees privacy and individuality as well as spaces for association, and thermal and visual comfort, while also providing employers an economic use of space, flexibility, and better worker psychology. The idea was to create a pleasant workplace—with an informal layout, wall-to-wall carpeting, and profuse plantings--, which was also commercially viable. Indeed, pleasantness was presented as expedient to productivity. In addition to a fifteen percent increase in net usable floor area made possible by deep floor plates, and the absence of partitioning that was expensive and difficult to move, a contented body of employees would work more efficiently and contribute to cost savings. While Duffy admitted the relatively high cost of mechanical services in landscaped offices—over 30% of a total building cost—he argued that a controlled environment would best accommodate the needs of a large staff distributed across a deep building: “An entirely artificial environment can be controlled, and comfortable conditions of temperature, humidity, clean and fresh air are provided for the whole staff, whatever the

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368 Duffy, Office Landscaping, 16-18.
This landscaped interior environment, constantly pleasant and comfortable, was advanced as a mechanism for profitability in the new postindustrial age.

Efforts to understand how the landscaped office’s social and aesthetic aspects were interrelated with economies of research, construction, and environmental management epitomized the fissure between the realms of art and science in postwar Britain. Most research on office design focused on thermal conditions, and there remained a dearth of research on the social effects of such planning. In an article on “Research and Burolandschaft,” Barry Poyner argued that the quality of such office planning was “not a problem of environmental physics, but one concerned with the relationships between people at work and how new kinds of environment affect these relationships. It is a social, psychological and organizational problem.”

Because of their entanglements with the corporate world, studies on the psychological effects of office planning and new interior environments usually remained confidential, and Poyner cited the Pilkington Research Unit (PRU) as the first non-governmental agency in Britain to publicly address the relationship between social, technical, and environmental aspects of office planning.

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369 Ibid., 18.
371 Ibid. “Although it did not specifically study Burolandschaft, the section contributed by Brian Wells in particular did study the difference between people’s attitudes and behavior in large and small office areas…Another psychologist, David Canter, who was originally involved in the Pilkington Research Unit, was also interested in the effects of office size…Canter did not investigate Bürolandschaft, but he seems to have been the only researcher to measure the effect of office environment on individual performance. Attempts have been made to measure the claimed increase in overall efficiency of Bürolandschaft, but technical difficulties have prevented all but quite trivial measurements of routine tasks being made. It is reported, for examples, that after the
The PRU was established in 1959 when Pilkington Brothers Glass, collaborating with the newly formed Department of Building Science at Liverpool University, undertook a study to compare day-lit and windowless factory environments. This study was eventually expanded to address “the interdependence of the many components that comprise a ‘total environment.’” 372 The aim was to produce knowledge relating to insulation, lighting, etc. that might be useful to the glass industry, but in a supposedly impartial way. The study investigated specific building types—factories, offices, primary schools, and mental hospitals—as a method of studying environments in their totalities. Multi-disciplinary teams were assembled to examine interdependent concerns of the built environment, rather than isolated technical questions. 373

For the second phase of research, which focused on the office typology, the team included an architect, a psychologist, a geographer, a physicist, and a secretary and a technician, in order to develop a “‘global’ picture of the characteristic environment.” 374 The team distinguished between slab and deep plan office buildings, and determined that while office workers prized day-lighting and exterior views, even workers positioned 70 feet or more from external windows tended to overestimate the proportion of daylight in

move to the government offices at Kew, the output of cleared invoices and stores instructions by clerical staff increased by between eight and fourteen per cent.”

372 Peter Manning, “United Kingdom: Windows, Environment and People [the work of the Pilkington Research Unit, 1959-1967],” *Arena/Interbuild* 83, 14 (Oct. 1967), 21. Manning was formerly director of the PRU. While the work of the PRU was financed by Pilkington, its staff were appointed and paid by Liverpool University. A guidance committee chaired by architect George Grenfell-Baines included members from the BRS, Pilkington, and Liverpool University.

373 Peter Manning, “Multi-disciplinary Research for Architecture [Pilkington Research Unit],” *Architects’ Journal* 146, 20 (Nov. 1967), 1239. “Until recently most architectural research workers have concerned themselves with individual facets of the design or construction tasks; few have attempted to explore the interaction of the components of a total problem.”

overall illumination levels [Fig. 3.64-3.65]. The study therefore concluded that the subjective aspects of the lighting environment had more impact than any quantifiable measures:

The uniquely important characteristics of windows appears to be their provision of a view: people within buildings seem to have a deep psychological need for some contact with the outside world…In present circumstances of virtually unlimited opportunities for alternative clerical employment it is unlikely that windowless conditions would be generally tolerated in small offices accommodating, say, up to 20 people in one room. On the other hand, open plan offices accommodating, perhaps, 200 or more people and large enough to provide ‘internal views’ probably would be.375

This finding on the aesthetic value of illumination and the provision of views seemed to corroborate the principal of outside awareness that Foster Associates had drawn from IBM. The PRU concluded that the quality or character of environment, an increasingly prevalent term in the late-1960s, was frequently at odds with the expediencies of industrialized building production, and offered the notion of adaptability—in the form of planning modules, flexible floor planning, ability for horizontal expansion, etc.—as one means of counteracting this condition [Fig. 3.66].376 Pilkington also established a Daylight Advisory Service, which was extended in the late-1960s to become the Environmental Advisory Service, which researched the relationship between windows and interior environments through visual studies; photometric studies using artificial skies; geometric studies of solar illumination; and studies of thermal comfort, condensation, shading, sound transfer [Fig. 3.67-3.69].377

375 Ibid.
In April 1969 Pilkington published research by its Environmental Advisory Service in a supplement to *The Architects’ Journal*. Titled “Counting the Cost of Air-Conditioning and Glazing,” the report examined the relationship between modern, extensively glazed building forms and mechanical air-conditioning, which it defined as controlled ventilation with heating, cooling, humidity control, and air filtering [Fig. 3.70]. The report’s aim was to evaluate Pilkington’s recently developed solar heat rejecting glass in its capacity to provide thermal comfort at a minimum cost.\(^{378}\) Outlining the loss of thermal capacity in heavily glazed buildings, an increase in fully sealed buildings due to air and noise pollution, and rising levels of artificial illumination, the report asserted that air-conditioning was necessity in contemporary building: “The case for air-conditioning as a desirable feature of modern building is incontrovertible, although sheer economics may at present limit its use in some places. The task of overcoming this cost problem is one which will call for increasing co-operation between architects and air-conditioning engineers.”\(^{379}\)

Given the widespread demand for full air-conditioning, the report went on to analyze the ways in which heat-rejecting glass might reduce costs, namely through limiting the transmission of light and heat.\(^{380}\) To evaluate cost-efficiency, it measured the increased cost of heat-rejecting glass against projected decreased costs in air-conditioning: a ninety-by-ninety-foot square building with ten-foot storey heights and seventy percent external glazing of heat-rejecting glass was estimated to offer overall air-

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\(^{379}\) Ibid.

\(^{380}\) The report also examined the impact of heat-rejecting glass on the visual lighting environment, concluding that this type of glazing had a bigger effect on controlling sky glare than a reduction in window size.
conditioning savings of 2.8 shillings per square foot over conventional clear glazing.\textsuperscript{381}

While this rate was not presented as a definitive standard, it was intended to demonstrate the interconnected economic and environmental advantages of specifying Pilkington’s newly developed product for fully air-conditioned buildings. As a complement to Pilkington’s research on the qualitative aspects of office environments and the sociological implications of such, this report provided hard data to rationalize the turn towards fully sealed and environmentally controlled buildings, which was slowly beginning in Britain during the late 1960s. With cost as the bottom line, the provision of air-conditioning would only be accepted if it could meet the manifold qualitative and quantitative demands of corporations, their employees, and property developers.

**Bubbles of Productivity**

The viability of this emerging paradigm of deep space and thin shell buildings with flexible landscaped interiors was consequent to a changing business culture. According to Francis Duffy, the marketability of such buildings would depend upon a recalibration of corporate clients’ needs with the forces of real estate development:

> If the idea of ‘landscaped’ offices is to be even more widely adopted in Britain, office users must insist upon getting the working conditions they really need, rather than what property men decree. In Germany, virtually all the existing ‘landscaped’ offices were commissioned by the firms themselves, with a direct and clear link between architect, O&M team and client…Perhaps we may look forward to the day when buildings and floors ‘suitable for landscaping’ are available in different sizes to suit different firms’ requirements.\textsuperscript{382}

\textsuperscript{381} Ibid.
\textsuperscript{382} Duffy, *Office Landscaping*, 20.
In a continuation of this proposal to wrest the design and management of office space from the control of property developers, who preferred the reliable equation of narrow shell-and-core office towers, Duffy developed the concept of separating a building’s exterior, or “shell,” from all moveable accommodations on the interior, which he called “scenery.” This division of shell and scenery in deep-plan office buildings predicted the formal development of office space seen in the Willis Faber & Dumas building and its descendents, whose external envelopes sheathed blank interiors ready to be animated by a changing roster of scenographic components [Fig. 3.71].

In a November 1971 design progress report for Willis Faber & Dumas entitled “The Case for Air Conditioning,” Foster Associates presented the building as a showpiece of air-conditioning technology. Compared to the United States, where air-conditioning had become standard, British office buildings of the 1960s and early 1970s still tended to adopt the shallow floor-plates and operable windows typical of postwar office buildings, primarily due to the expense of mechanical ventilation and air-

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384 See “Bürolandschaft: An Appraisal,” by Francis Duffy and Colin Cave in Francis Duffy, Colin Cave, and John Worthington, eds., Planning Office Space (London: Architectural Press; New York: Nichols Pub. Co., 1976), 40. On the problem of bigness in early bürolandschaft developments, Duffy and Cave write: “The central theme of the protagonists of bürolandschaft, and one to which other management consultants as well as architects and interior designers were particularly susceptible, was the proposition that offices (viewed as factories) required large undivided spaces. Offices are factories in the sense that information, transmitted on paper or tape, fed along telephone lines, encapsulated in recorded decisions and so on is the raw material for processing rather than a soup of chemicals or minerals.”
385 “The Case for Air Conditioning,” November 17, 1971. Foster Associates Progress Reports 19/12/72-13/2/73. F+P Archives, BOX 0006/1D; 26902. The report outlined the historical context of office buildings after World War II: the advent of the curtain wall—and increased external glazing and deeper floor-plates—in the 1950s; greater solar gain and large portions of interior space with no access to natural light or ventilation; and the necessary implementation of both artificial lighting and air-conditioning.
conditioning systems required for deep-plan buildings. The progress report noted a recent shift in the British real estate economy which made air-conditioned buildings a practical possibility: "…there is a detectable trend towards installation of air conditioning in speculative office developments located near the centres of major cities in the United Kingdom: the trend has been created by the tendency for rents to rise faster than air conditioning costs." Francis Duffy had posited that the differentiation of shell and scenery, despite significant cost outlay, would better meet corporate clients’ need for flexible working environments. Here, in their “Case for Air Conditioning,” Foster Associates argued that rising rents in the early 1970s effectively paid for the implementation of such ‘shell and scenery’ building forms and their attendant mechanical systems—hollow but expensive cavities of air.

This typology, with thin outer shell as interface between the interior atmosphere and the surrounding environment, was presaged in Buckminster Fuller’s concept of environment controlling, wherein a building was reduced to a climate-controlling membrane encapsulating interior space. While it initially took the form of a mast structure with suspended skin, the idea was later translated to the form of a dome, the result of Fuller’s postulation that spheres and bubbles were the ideal forms to conserve energy. Spheres divided the world into an internal system and anything external to it, with no loss of energy between the two domains; bubbles were essentially tension

networks, with the movement of interior air molecules pushing against a distended “molecule-thin” surface.\textsuperscript{388} Fuller’s unbuilt project for a dome over Manhattan, designed with Shoji Sadao in 1960, presented this concept at an urban scale; the idea was that all buildings contained within the dome’s span over midtown Manhattan would share the same heating and cooling, thereby reducing overall energy consumption. The Climatron greenhouse at the Missouri Botanical Garden in St. Louis, built the same year, was in many ways a materialization of Fuller’s environment controlling concept, with a loose domed skin kept entirely separate from interior structures such as floors, escalators, and walkways, predicting Francis Duffy’s separation of shell and scenery [Fig. 3.72].\textsuperscript{389}

In 1971, as Foster Associates office began work on the Willis Faber & Dumas building, they began to collaborate with Buckminster Fuller on a conceptual project they called “Climatroffice.” Envisioned as a means of enveloping a number of different spatial zones within a single loose-fit ovoid dome—a form capable of enclosing maximum volume with minimum surface—, the project proposed a shared interior microclimate with plantings to create a ‘living office’ environment [Fig. 3.73].\textsuperscript{390} The flexible interior, with movable floors and spatial divisions, was intended to maintain direct visual contact to the city outside through a continuous transparent skin. According to Foster the project “points towards an architecture of ‘interiorised’ buildings, which live within an envelope

\textsuperscript{389} See Joachim Krausse, “Thinking and Building,” 69-70. Krause claims that Fuller’s Climatron in St. Louis (1960) and the Montreal EXPO-dome (1967) were successful realizations of the concept of intelligent environment controlling. Murphy and Mackey Architects designed the Climatron using principles that they learned from Buckminster Fuller, who lived 100 miles away in Carbondale, Illinois. See “The Climatron: Missouri Botanical Gardens, St. Louis,” \textit{AIA Journal} 35 (May 1961), 27-32.
\textsuperscript{390} David Jenkins, ed., \textit{Works / Norman Foster I} (Munich; New York: Prestel, 2002), 540.
so diaphanous that its presence is perceived as being closer to the sky or clouds than any conventional structure.”⁵³⁹¹ Early design development sketches for the Willis Faber & Dumas building featured a continuous glass envelope loosely encompassing stacked floor plates punctured by circulation routes and dotted with green plantings [Fig. 3.74]. The final building’s minimized undulating façade and green-carpeted landscaped interior echoed some of the ideas developed for Climatroffice, although Foster claimed that his practice was driven more by social values than the design of any technical hardware in developing a prototypical workspace environment, arguing that their collaborations with Fuller were evidence of an endeavor to implement “appropriate technologies to social goals.”⁵³⁹² In the case of Willis Faber & Dumas, this translated to expansive open-plan floor plates that were penetrated by a large central full-height sky-lit atrium with escalator, offering free movement and unhindered social contact between company employees [Fig. 3.75-3.76]. Foster presented the scarcity of visual obstructions between workspaces as a concretization of the ‘open door’ policy that managers had adopted in previous offices.⁵³⁹³ This spatial liberation of the workforce was combined with the provision of daily comforts such as a ground floor pool, a rooftop garden, and a sun-drenched café at the top of the building, all of which were intended to entice workers to leave the drudgery of the City of London for a clean, calm, spacious working environment in a quiet Suffolk town [Fig. 3.77-3.78].

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⁵³⁹¹ Norman Foster quoted in Jenkins, Works / Norman Foster 1, 540.
⁵³⁹³ Ibid. “Movement is open, literally in the sun, and social contact is natural and relaxed across the spectrum of the company. Orientation is immediate; you always know where you are. The barriers are few and seldom visual.”
This shift from a hierarchical model of office building, which reserved high-end materials and light-filled spaces exclusively for executive quarters, to a more even spatial distribution and finely-detailed assemblies of relatively cheap materials also reflected the evolving commercial tactic of creating more comfortable, and pleasurable, facilities for office workers. On this Foster was influenced by the work of another American technocrat, Herman Kahn, a systems theorist with experience developing military strategy for the RAND Corporation. Kahn’s Hudson Institute published various projections on global economic development and social change from the 1960s on, and Foster cited its prognostications regarding the future of workspace as informing his conceptualization of the Willis Faber & Dumas building: "I remember at the time, Herman Kahn, futurologist of the Hudson Institute, made the point that office environments that failed to anticipate social change by raising standards and providing staff amenities would become obsolete. This was not about philanthropy, simply the reality of changing levels of expectation." This kind of commercial pragmatism used to justify the spatial and social programs of the building reflected the claims of efficiency and economy that the architects used to substantiate the building’s technical makeup. All of this signaled an insular focus on the needs of corporate clients and their middle-class employees through the provision of comfort, convenience, and pleasure.

395 Reporting on Herman Kahn’s 1969 address to a group of British businessmen at a London hotel, Charles Jencks derided his technocratic approach as falsely altruistic and destructively anti-ideological. He characterized Kahn as “a man who could map out 193 clear steps towards total nuclear war and then stop to work out the subtleties of the next step--194, total destruction of all life--all for the 'humanistic' reason of making alternatives more clear and action more 'humane'." Charles Jencks, “The
In 1967 Herman Kahn published *The Year 2000: A Framework for Speculation on the Next Thirty-three Years*, a wide-reaching compilation of social and economic theory, analysis of technological change, and predictions of global politics [Fig. 3.79]. There he projected that the final third of the twentieth century would witness a shift away from production-oriented economic activity towards a service-oriented economy. Kahn anticipated a parallel shift towards “‘postindustrial’ culture,” which would be defined by a diminished value of work and achievement in the middle classes and the emergence of what Kahn termed “sensate, secular, humanist, perhaps self-indulgent criteria…” In a paper delivered at a 1970 conference on “The Future of the Corporation” Kahn spoke of an impending “1985 technological crisis” involving environmental degradation, pollution, and the onset of increasingly dangerous technologies and political situations, which he posited would have “a profound political, moral, morale, and psychological effect on many upper-class and middle-class young people.”

Echoing Daniel Bell’s


397 Ibid., 23-25. A table of *One Hundred Technical Innovations Very Likely in the Last Third of the Twentieth Century* included: “[e]xtreme high-strength and/or high-temperature structural materials,” “[m]ore reliable and longer-range weather forecasting,” “[n]ew techniques for preserving or improving the environment,” “[m]ore sophisticated architectural engineering (e.g., geodesic domes, ‘fancy’ stressed shells, pressurized skins, and esoteric materials),” “[s]ome control of weather and climate,” “[d]esign and extensive use of responsive and supercontrolled environments for private and public use (for pleasurable, educational, and vocational purposes),” “[n]ew and improved materials and equipment for buildings and interiors (e.g., variable transmission glass, heating and cooling by thermoelectric effect, and electroluminescent and phosphorescent lighting).”

argument on post-industrial culture, presented at the same conference, Kahn suggested that these young people would begin a “‘search for meaning and purpose’” in response to the technological crisis. This, he reflected in a summation of the conference’s findings, could be linked to the demands these affluent young people would make when they became employees of corporations. Arguing that the “problems” facing corporations in the 1970s and 1980s would stem from prosperity rather than poverty, and a general shift away from an economy of production towards one of services and “nonessential consumption,” Kahn forecast certain transformations in the culture of corporations, including: “Emphasis on the technology and other requirements of social and environmental engineering and on stricter and more explicit criteria relating to health, safety, recreation, self-actualization, aesthetics, etc. as they affect both the employees of the corporation and the community at large.” This would be reflected in employees’ unexpected overtones. For example, someone has calculated that the temperature of New York City is some five degrees hotter in the summer because of the ejection of heat by air-conditioning equipment. The issue could be formulated as a matter of the rich ejecting heat (i.e., excreting the waste products of the air-conditioner) upon the people in the street and on the poor who do not possess air-conditioning. If this last were completely true it could become a very bitter political issue, but luckily in New York City a good many of the poor also have air-conditioning. But in any case it is clear that you may be able to tolerate a five-degree increase in the heat of the city streets, but you cannot allow many doublings of this increase. You just do not want ten or twenty degrees extra summer heat for those without—or outside—air-conditioning.”

399 Ibid., 123-124. Kahn referred here to the argument that Daniel Bell presented in his paper for the conference, entitled “The Post-Industrial Society—Expectations for the 1970s and 1980s,” explaining that “Bell has already mentioned that the politics of 1975-1985 will very likely be different from today. Politics will be less about the distribution of shares of GNP than about ideological issues, about the good life, what one means by a humanistic philosophy.”

growing interest in “noneconomic incentives” such as “organizational ‘personality’ and ambience…”

Kahn was careful to distinguish his own method of future studies from what he called a Neo-Malthusian approach, which pitted global economic and population growth against quality of life and the health of the environment [Fig. 3.80-3.81]. Kahn’s own image of the post-industrial, super-industrial future projected rising wealth, a decrease in poverty through technological advancements, and “a materially abundant life for almost all.” Framing this drive towards commercial prosperity as a socially benevolent stance, Kahn argued that this abundance for almost all would be brought about by “a project to improve productivity.”

401 Ibid., 204-205.
403 Ibid. Kahn compared this project for increased productivity to what he regarded as the selfish act of ‘dropping out.’ He explained that a typical Neo-Malthusian “would regard a man who ‘drops out’ as doing God’s work, and a project to improve productivity as a crime against humanity.” Charles Jencks had previously paraphrased Kahn on his disparagement of hippies. See Charles Jencks, “The Religious Con-version of Herman Kahn,” AAQ: Architectural Association Quarterly 1, 4 (Oct. 1969), 66. “'I know more about every group in the world, excluding the Nazis, than that group knows about itself. We study them all at the Hudson Institute. We run through all the scenarios, take on all their ideologies and bring them out into the open...My nephews are Hippies and like all Hippies they're nice kids, but personally I can't stand them. They all want something for nothing. They're all spoiled, upper-middle-class kids who want to drop out and get paid for it. The thing is that they can work one month in twelve at the Post Office, get 500 dollars and then live for the next 11 months off these earnings. They live on ten dollars per week and they live like pigs which is all right if they want to--a lot of people will be dropping out in the next 30 years. That's OK. The problem is, however, these Hippies want to be paid for dropping out--get on the dole--and that's downright degenerate. They won't get a penny of mine, or the government's I hope.'"
This enhanced state of productivity can be understood to have supplanted product in post-industrial society, as commodities and consumption were replaced by services and enterprise in a neoliberal economy that framed individual subjects as human capital.\textsuperscript{404} What Herman Kahn presented as a search for meaning and value, and the provision of “noneconomic incentives” like ambiance and organizational personality, Michel Foucault described as an ordoliberal modeling of the social in terms of enterprise, offering ‘warm’ cultural values in contradistinction to ‘cold’ competition: “The enterprise schema involves acting so that the individual, to use the classical and fashionable terminology of their time, is not alienated from his work environment, from the time of his life, from his household, his family, and from the natural environment.”\textsuperscript{405} The Climatroffice prototype imagined by Fuller and Foster—a managed environment supporting flexible spatial arrangements and equipped with various enhancements to the corporate charisma through its milieu—aligned with Kahn’s recommendations on the installation of social programs for calculated commercial ends. This bubble of productivity encapsulated that atmosphere of enterprise described by Foucault, in which the celebration of individuals’ engagement with the work environment indicated a ‘warming up’ of the transactional domain.

\textsuperscript{404} See Wendy Brown, \textit{Undoing the Demos: Neoliberalism’s Stealth Revolution} (New York: Zone Books, 2015), 65-66. “From the replacement of exchange by competition as the market’s fundamental value and from the establishment of economic subjects as human capital, it follows that an emphasis on entrepreneurship and productivity replaces an emphasis on commodities and consumption. Productivity is prioritized over product; enterprise is prioritized over consumption or satisfaction. An enterprise society is not about trucking and bartering things (exchange), nor is it based on desires or appetites for things (consumption). It is economic in an entirely different sense.”

In place of a tectonic understanding of architecture, with legible structure and systems, here the most advanced technologies employed were those that rendered the building less and less visible, less and less material [Fig. 3.82-3.83]. The precise detailing of the exterior enclosure and the precise management of interior systems produced a condition of emptiness, in which an emphasis upon thermal and visual comfort resulted in an interior ambience that helped to define the aesthetics of the organizational personality. This bubble of productivity was specified by its environment, both technically, through the ‘case for air-conditioning,’ and through its simulated and actual gardens, pools, and sunbeams; the upgraded interior provided the infrastructure and atmospheric conditions to support work elevated by leisure, exercise, and sustenance. The flexibility used to rationalize the open-plan interiors of the landscaped office space accompanied a stripping down of the physical artifact of building to mere shell, a mirrored, shape-shifting skin; even the mirrored ceilings of office spaces further dissolved the building’s material presence [Fig. 3.84]. The editors of the *Architectural Review* described the building as indistinguishable: "...since the incidents of the design-- the fixings and the joints-- are minimised to the point of disappearance, it is, of its nature, an eliminator of particularity."406 But rather than being generic, this minimized exterior functioned as a most pristine casing, a treatment of building as container or package, the inverse of which was the inwardly focused infusion of warm enhancements to the cool world of financial services.

This comfortable immersion within the machinations of risk management in the mid-1970s was a distraction from the realities of Britain’s multi-year recession and

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energy shortage due to the worldwide oil crisis. Globally, the collapse of the Bretton Woods system during the late 1960s and early 1970s and the subsequent introduction of floating exchange rates led to escalating volatility in a financial market that now carried evident risks. These were to be managed using new tools including futures, forwards, and foreign currency options, all of which complicated the operations of the global insurance industry, of which Willis Faber & Dumas was a significant agent.\footnote{Michel Crouhy, Dan Galai, and Robert Mark, \textit{Risk Management} (New York: McGraw Hill, 2000), 1-12.} While economic growth resumed in Britain in 1975, the year the Ipswich building opened, and Willis, Faber & Dumas were listed on the London Stock Exchange in 1976, indicating the company’s status as the preeminent British insurance broker, nation-wide instability persisted. Unemployment reached severe levels and the public sector was crippled by worker strikes, ultimately leading to the collapse of the Labour government in 1979. Such increasingly hazardous fiscal, political, and environmental climates—both nationally and globally—complicated the various methods of speculation enacted by concerns such as Willis, Faber & Dumas, who, in addition to underwriting global ventures related to construction, energy, and aerospace technologies, were involved in more convoluted processes of mutualized risk management. In the mid-1970s they became one of the largest member agents of the Lloyd’s of London Corporation, a marketplace for general insurance and reinsurance, in which capacity they advised individual members of the corporation (who assumed complete personal liability) on the risks and procedures of
insurance underwriting. The intricacies of such market dealings were given a tranquil air in Foster Associates’ building for Willis Faber & Dumas.

While Fredric Jameson posited that “the world space of multinational capital”—the various forms of corporate space that we confront throughout our cities—is defined by spatial disorientation and distraction, which effectively alienate individuals from political or collective action, the kind of serene interior created at the Willis, Faber & Dumas headquarters produced a similar effect through opposite means. There, comfort and entertainment diverted attention from the organization’s entanglement within contemporary economic and political complexities. In place of bewilderment and messiness was a simulated garden of delight. The problem of representational incommensurability that Jameson describes, in which the visible reality of economic and social injustice confronts the simultaneous reality of an abstract financial system with diffuse power structures, is disregarded in the aesthetic gloss of this idealized sealed interior.

The Corporation of Lloyd’s, which was formed in the 1771 reorganization of the bank, does not directly insure anyone but rather has individual members or names, who provide insurance with unlimited liability through syndicates. Lloyds regulates members’ financial status and gives generalized support for their operations. Members agents advise names on which syndicates to join, in addition to outlining financial risks. See Stephen Valdez, An Introduction to Western Financial Markets (Houndmills, Basingstoke, Hampshire: The Macmillan Press, 1993): 262-263.

“…the new political art (if it is possible at all) will have to hold to the truth of postmodernism, that is to say, to its fundamental object—the world space of multinational capital—at the same time at which it achieves a breakthrough to some as yet unimaginable new mode of representing this last, in which we may again begin to grasp our positioning as individual and collective subjects and regain a capacity to act and struggle which is at present neutralized by our spatial as well as our social confusion.” Fredric Jameson, Postmodernism, or, The Cultural Logic of Late Capitalism, 54.

Ibid., 127-128.
The techniques of enclosure and environmental management employed at Willis Faber & Dumas were instrumental in producing this postmodern paradigm of empty space. The peculiar social world it circumscribed propped up the institutions of risk management and financial services, which now relied upon a strict cutting off from the more wide-reaching social circumstances of the era, a closing inward against a convoluted world. Grappling with the desolation of the 1970s, and a lack of engagement with modernism’s own past and a disengagement from its ghosts, Marshall Berman exhorted his acquiescent contemporaries to burst through their sealed containers and reform communities of engaged, hopeful individuals: “Maybe the moderns of the 1970s will rest content in the artificial inner light of their inflated domes. Or maybe, someday soon, they will lift the domes through their picture windows, open their windows to one another, and work to create a politics of authenticity that will embrace us all...”\(^{411}\) Rather than treating community as extensive and diverse, the paradigm created at Willis Faber & Dumas replaced social authenticity with a superficial accommodation of presumed desires, a semblance of conformation to individuals’ yearnings intended to induce a state of amnesia precluding any need for personal expression. This was a model of corporate space that Norman Foster and his associates replicated in numerous subsequent projects for clients in the financial sector, such as the Commerzbank Headquarters in Frankfurt, billed as the world’s first ecological office tower, with spiraling internal winter gardens offering fresh air and space for social interaction, or the 30 St. Mary Axe building for

Swiss Re in London, which adopted a similar configuration. Predicting these later works, the architecture of nothing developed for Willis Faber & Dumas produced a social and political sterility that, much as Berman suggested, could only be countered by a breach of those sealed membranes confining postmodern interiority.
Chapter 4:  
The Value of Enclosure: Environmental Performance and Commercial Viability at the HSBC Headquarters, 1979-1986

What does it mean for a technical object to generate controversy? How are the ambitions of various collaborators manifested within the development of a technique, and what do disputes regarding such reveal? How might a technical object of architecture become the seed for a spatial or environmental paradigm? Problems such as these pervaded the research, design, and construction processes in the development of the Hongkong and Shanghai Banking Corporation (HSBC) headquarters by Foster Associates. The architects won the commission by competition in 1979, based in large part upon their previous implementation of innovative construction methods in projects like the Willis Faber Dumas headquarters in Ipswich, England (1971-1975) and the Sainsbury Centre for Visual Arts in Norwich, England (1974-1978). HSBC was the practice’s first international project, and the building’s scale—in terms of its size, global visibility, and the extensive material networks required for its production—presented a unique challenge. Intricate exchanges between the client, architects, engineers were essential for the distribution of building components and systems that constituted the Bank’s membrane of enclosure and formed a new paradigm of regulated environment [Fig. 4.1].

The 1982 annual report to Hongkong and Shanghai Banking Corporation (HSBC) shareholders addressed recent speculation on escalating costs for the Bank’s new headquarters building, then under construction. Due in part to an already sizeable cost overrun in the steel subcontract resulting from a worldwide steel shortage, the building was rumored to be far in excess of costs forecasted at the project’s outset in 1980. The report explained that the construction cost of the “basic building…, excluding the special
costs of a banking operation,” was originally estimated at 1.4 billion Hong Kong dollars (HK$), which inflation would push to 2.5 billion by the building’s completion at the end of 1985. With an escalation in steel cost this figure reached 3 billion HK$, but the report argued that the building’s flexible design had the capacity to accommodate future technological and economic change, stating: “…we believe that over the years it will prove to be a most cost-effective investment.”

Nevertheless, in 1983 a media uproar ensued, decrying the stratospheric cost of the new headquarters [Fig. 4.2]. The Sunday Telegraph of London reported a figure of over 8 billion HK$ for the overall cost of the building, the most expensive ever constructed, with a cost overrun 200% above the amount originally predicted. This worked out to nearly 11,000 HK$ per square foot, well in excess of other notable tall buildings, and eleven times the cost per square foot of Chicago’s Sears Tower in 1983 currency. The Hong Kong business newsletter Target Intelligence Report wrote that Bank Chairman Michael Sandberg’s commission of a high tech building by Foster Associates was going to cost shareholders of HSBC around 3 HK$ per share: “They fronted up the cash, and he got his building” [Fig. 4.3].

At issue in the controversy over the building’s exorbitant cost was a misunderstanding regarding the distinction between the appraised “shell cost” and the actual cost. For the purposes of the project, the shell cost was defined as the total for all

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items which “which a property development company would spend on an ordinary building.” The 1.4 billion HK$ budget reported to shareholders and approved by the Board of Directors in 1980 was for shell cost alone. The “fit-out,” with all “special requirements” to accommodate banking activity, was considered a business expense to be delegated to the board by chairman Sandberg. The total cost of the building including these special banking requirements was estimated in 1980 to be 2.36 billion HK$.

Volatile inflation rates in the period, as well as the unpredictable prices of components prefabricated in countries across the globe, made it difficult to calculate a final figure, so the bank developed a proprietary “Economic Intelligence Unit” and consulted a number of economic forecasters to project a total building cost in 1985 of 4.43 billion HK$, which the steel cost overrun pushed to 5 billion HK$ [Fig. 4.4].

HSBC undertook a number of financial assessment measures to determine whether the budget was justified. They attempted to estimate future savings generated by building features considered enhancements to banking activity, and under the advisement of a specialist consultant concluded that the building was satisfactorily cost-effective. The

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415 Article on 1 QRC to be sent to all Staff, sent from RV Munden to JRP Breen, Jan. 18, 1984 (F+P Archives, F22167 Client Correspondence, c. Jan.-Nov. 1984), 2.
417 HSBC’s internally-issued article suggested that the 1982 steel cost overrun alone, an entirely unforeseeable event, could be made to account for the project’s escalated costs, and argued that the HKD 5 billion figure could not be understood in isolation, as export credit finance and other tax benefits not readily apparent in this base figure would provide long-term savings. At the same time the article asserted that the project, probably the largest structural steel contract in terms of man-hours to have been awarded since the construction of the Sydney Harbour Bridge, played a major part in keeping important sections of the UK steel industry alive in 1982 and 1983. See Article on 1 QRC to be sent to all Staff, sent from Roy V. Munden to JRP Breen, Jan. 18, 1984. F+P Archives, F22167 Client Correspondence, c. Jan.-Nov. 1984, 1-3, 14.
“commercial viability” of the building as a whole was figured by calculating the Internal Rate of Return on the project, comparing this with anticipated revenue on other possible investments of funds, such as fixed deposit with definite returns. Considering assumptions like future running costs, the total capital cost of the building—i.e. capital construction cost plus special banking features cost—showed an Internal Rate of Return of 13% per year over a 50-year period. Bank management insisted that the building would not change the bank’s policy of maintaining high liquidity, and that “the competitive advantages provided by the building added to the true Internal Rate of Return which will be received, can only serve to enhance profits.”

At the outset of the design for the new headquarters, Foster Associates partner Spencer de Grey dismissed a cost report by quantity surveyors Levett & Bailey that compared the design scheme to a “typical Hong Kong office building,” arguing that the typical building was merely hypothetical [Fig. 4.5]. In order to fully appraise the owner-occupied new headquarters, de Grey insisted, the client had to answer some fundamental questions, such as: “If the building is designed to generate profitable activity, what is the optimum level of first cost and on what basis do you assess it?,” “If the building is designed for…adaptability to changing business methods or technologies, what first cost level would be appropriate?,” “Is there a way of assigning an appropriate value to prestige, image, or landmark qualities?,” and “What is the appropriate financial assessment basis for energy conservation and maintenance costs, short term and long term?”

418 Ibid.
At stake here was an attempt to understand the relationship between the cost of
the building—to many minds excessive—and the techniques employed, and to reconcile
these with value and growth over time. This chapter examines how one technical
element, the headquarters’ glazed envelope, exemplified the slippery nature of both cost
and performance in the design of the headquarters. Various assessments of profitability,
technical standards, and energy criteria were used to project future efficacy, which was
presented in terms of recompense for the risks of capital expenditure. As such, this tightly
regulated enclosure became an instrument to sustain the enterprise of a corporate bank
with expanding global reach during a period of political and economic flux.

In September of 1981 HSBC’s board approved a budget of 422 million HK$ in
basic costs for the headquarters’ cladding and glazing, to which was added a “fit-out”
budget of 224 million HK$ to complement special banking requirements, indicating that
one third of the cladding and glazing budget was allocated to business expenses rather
than construction costs.\footnote{420} By treating the envelope as an enhancement to the business of
banking, its future performance was couched in terms of projected returns on the assets
vented for its production. The glazed curtain wall subcontract package was one of the
largest, at 593 million HK$, compared to 563 million HK$ for steel and 389 million HK$
for the external service modules.\footnote{421} Given its cost and prominence, the detailing of the
approximately 344,000-square-foot envelope proved a pivotal aspect of the building’s
design.

\footnote{420} Memo from G Graham to Spencer de Grey, Feb. 22, 1982, re HSPM Papers on Cost.
F+P Archive, F17375 Client Correspondence, c. c. Jan.-May 1982. Both figures included
an inflation allowance to 1985.

\footnote{421} Press release from Management Contractors Lok Wimpey, c. July 30, 1982. F+P
In 1981 St-Louis based cladding manufacturers Cupples Products were awarded the glass curtain wall and aluminum cladding contract for the new HSBC headquarters, valued at over 100 million United States dollars (US$). At the time, Cupples maintained the largest curtain wall, window, and ornamental metal plant in the world; it had developed curtain walls for a number of the world’s notable tall buildings, including the World Trade Center towers in New York and Sears Tower in Chicago [Fig. 4.6]. Its in-house engineering, design, testing, and fabrication divisions made it possible for a single contractor to realize a curtain wall in its entirety, thereby avoiding discrepancies between components or stages of manufacture [Fig. 4.7]. Cupples’ extensive equipment for static, dynamic, thermal and seismic testing of mock-ups ensured curtain walls’ performance in the field, diminishing water or air leakage to create tightly sealed membranes.

422 Draft of press release on Cupples Appointment to HSBC Project, Sept. 23, 1981. F+P Archives, F17784 Client correspondence, c. Jun.-Oct. 1981. The glazed envelope itself was estimated to cost around 58 million GBP. Press release from Lok Wimpey, c. July 30, 1982. F+P Archives, F17725 Client correspondence, c. Jul.-Aug. 1982. In an October 1982 press release the Pittsburgh-based Alcoa company wrote that the nearly seven million pounds of aluminum it would supply for the honeycomb curtain wall cladding system by Cupples and the honeycomb accessible flooring would be one of the largest implementations of Alcoa metal in a foreign building: “The imaginatively designed structure, which reveals its entire support structure inside and out, will be sheathed in fluoropolymer-coated aluminum curtain wall cladding. Cupples will manufacture plate and honeycomb panels from over two million pounds of Alcoa 3003-H14 sheet, which is known for its flatness and good formability qualities. The cladding is being matched with almost jewel-like precision at Cupples’ St. Louis plant and will be coded numerically for easy on-site assembly. The curtain wall system will be shipped next June to Hong Kong, where it will be erected under Cupples’ supervision. Cupples will extrude the wall system and various interior applications from four million pounds of Alcoa aluminum ingot.” Draft of ALCOA’s resubmitted press release Oct. 28, 1982. F+P Archives, F17722 Client correspondence, c. Nov. 1982.

As the project progressed from early conversations about the bank’s image to the materialization of the new headquarters’ skin, questions of appearance confronted critical energy issues. Journalist Stephanie Williams wrote to Foster from Hong Kong in 1980: “The fact that you are even taking the energy question seriously is entirely revolutionary out here, as I am sure you know.” While the 1973 oil crisis had precipitated increased concern for reducing energy consumption in buildings, the issue had received the most attention in Western Europe and the United States, where architects and engineers tended to focus on strategies for passive solar heating and the use of simple low-tech building techniques. In their collaboration with Cupples, Foster Associates hoped to design and fabricate an envelope that would provide maximum protection against thermal gain and still meet the client’s visibility demands, all while adhering to the rigorous standards of precise prefabrication and installation required of a building whose components would be shipped from around the world to be assembled on site. Any errors in this process would result not only in lost time but also, critically, in cost overrun.

In addition, the incorporation of new computer technologies impacted the design of the HSBC headquarters in several ways. First, it influenced the development of glass facades as the architects and consultants had to consider how screens on computer workstations would interact with the glazed envelope in their figuring of appropriate

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lighting levels and spatial arrangements. The headquarters also incorporated newly developed computerized building management systems for optimal accuracy and efficiency in environmental controls. In addition, as a globally circulated image, the building itself was to transmit a faith in the capacity of technology and systems to address the financial and environmental complexities of the period.

The relationship between profitability, value, and precise environmental calibration was tested in the processes of research and design development for the building’s typical glazed curtain wall. By May of 1982, Foster Associates were exploring the option of a sandwiched curtain wall with clear external glazing supplied by Cupples to provide a weatherproof enclosure, and a second skin of high performance glass to improve the envelope’s thermal performance through shading and glare control. An adjustable blind positioned between the two skins was to be locally controlled but also integrated with the automated building management system. This binary skin solution presented particular technical challenges, not least of which was the problem of how to detail the many penetrations of the structure through the envelope which occurred at mast areas and hanger penetrations, below refuge terraces, and at cutbacks on the building’s east face [Fig. 4.8-4.10]. These penetrations through the glass façade were not workable with a double-glazed system, but according to Foster Associates’ in-house mechanical engineer Loren Butt, who was responsible for developing all aspects of the energy scheme for HSBC (and for several previous projects including Willis Faber Dumas), eliminating entire panels of back-up wall at these locations would produce excessive heat gain, overloading the building’s cooling system [Fig. 4.11-4.12].

Reverting to a single-pane mirrored glass curtain wall would have provided a cheaper and simpler solution than the double-glazed skin, as it did not require a back-up system to satisfy energy requirements, but the architects sought to avoid that solution at all costs. While reflective glass performed well in terms of thermal insulation relative to indoor-outdoor temperature differentials, and corrected well for diffuse and direct solar heat gain, also tempering the contrast between bright external views and artificial lighting, Foster Associates cited a number of technical concerns with the material, presumably to bolster their objections to its visual effects. These included: diminished privacy from the exterior and a dark mirror effect from the interior at nighttime; the need for light control measures such as ultra-violet filtering; distracting direct views of the sun from inside; reflections of external views on computer screens during daytime; excessive work surface brightness from direct sun combined with artificial lighting; and a requirement to shield against re-radiation of heat from warm glass onto occupants, office equipment, furniture and fittings. The glass for the back-up wall option was calculated to cost nearly ten times the cost of standard single-pane reflective glass (at 21.6 million US$ versus 2.25 million US$), so its advantages in terms of energy efficiency and visual adjustability would have to be convincingly upheld.

Foster Associates explored a compromise solution combining reflective Libbey-Owens-Ford 1-108 glass with back-up panels installed only in certain office spaces, and

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427 Memo re “HSPM - External Wall,” from Loren Butt to Norman Foster, June 22, 1982. F+P Archives, ID 17949, BOX 0331, General FA Correspondence.
while this was more economical (with glass costing 11.25 million US$), and would not require such precise detailing as the standard double-glazed solution since it would eliminate the convergence of structural penetrations with back-up wall panels, they remained dissatisfied with the mirrored exterior surface it would present.\textsuperscript{430} Instead, the architects pursued a strategy of highlighting the performance of the sandwiched curtain wall system, arguing that compared to mirrored glass, a clear glass outer pane with a backup wall system transmitted only marginally more light (10 percent transmission versus 8 percent with mirror glass), with a slightly lower thermal insulation value (3.8 watts per square meter versus mirror glass’s 5.7 watts per square meter).\textsuperscript{431}

Both client and architect agreed that transparency was intrinsic to the image of the contemporary bank [Fig. 4.13]. HSBC’s operations were to be made visible to the world outside, and visual connections to the surrounding city and landscape would provide more pleasant and productive workspaces. Early design schemes emphasized the disintegration of the barrier between inside and out [Fig. 4.14–4.15].\textsuperscript{432}

The initial cost plan for the headquarters building accounted for a “developer’s standard” for external cladding and glazing, the exemplar of which was the Admiralty Centre just east of Hong Kong’s central business district [Fig. 4.16], a pair of towers which embodied economy with bronze reflective glass curtain walls, simple square floor

\textsuperscript{430} Ibid.
\textsuperscript{431} Telex re “Cladding Research,” from Loren Butt to Ray Guy of HSPM, July 6, 1982. F+P Archives, ID 17254, BOX 0230, Cladding Research, F0001045800.
\textsuperscript{432} In earlier studies, glass manufacturer Libbey-Owens-Ford had specified a silicone stopless glazing installation using their Vari-Tran 1-108 reflective tempered glass, which had a silver metallic coating to offset heat gain. [F+P Archives, R29758, Updated Proposal for WP 5100 Second Draft, Aug. 6-13, 1981 [Cupples Products]]. By December 1981 the decision had been made to use clear class on typical curtain wall and glazed grid wall. [F+P Archives, ID 17190, BOX 0228, Cupples [F0001045796]].
plans, and square central cores. At a July 1982 presentation to the bank’s board, Norman Foster compared the two options for the typical glazed curtain wall—mirrored glass, or the back-up wall for “enhanced performance”—reiterating his preference for the back-up wall, which was estimated to cost 20 million HK$ above the curtain wall shell cost of 100 million HK$ [Fig. 4.17-4.19]. Among other practical advantages he cited its improved acoustic performance, with slightly better sound reduction and the elimination of “drumming” at certain sound frequencies, as well as the avoidance of condensation on the outside glass surface. The board approved this solution, developed with Cupples, and agreed that 200,000 US$ (1.32 million HK$) should be paid to American glass manufacturer Corning Glass Works to cover all costs related to development and testing of glass products up to the production run.

Despite this provisional approval, with the caveat that any related additional costs remain under 20 million HK$ and the total cost of the external envelope not exceed 120 million HK$, board members still queried the double skin solution. While Foster had emphasized questions of performance, problems of image were foremost in their

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In a September 1982 letter to Foster, Roy Munden, general manager of planning for HSBC and chairman of the Hong Kong Shanghai Property Management group (HSPM), which was responsible for procuring a new headquarters building, waxed poetic about the splendors of the local surrounds as viewed through the bank’s temporary offices in the Admiralty Centre:

The other day I was gazing out of my office window seeking inspiration to solve a particularly knotty problem. We had suffered a long period of heavy rain but, as I watched, the sky began to clear. The dark clouds, borne on a brisk easterly wind, rushed across the harbour and headed out towards Lantau. The emerging sun lit remaining masses of white clouds as they quickly dispersed and large patches of cleanly washed blue sky appeared. All this beauty was, of course, subtly softened by the tinting effect of the mirror glass of Admiralty.

It occurred to me as I watched, that if I had been looking through two skins of glass and the inner one had a built-in venetian blind, I would not have been able to see the sky. This would clearly not meet the criterion we have agreed that at all times the inhabitants of 1 QRC should prefer to have the inner skin closed.

This has led me to the following conclusion:

‘Let not the dazzle of high technology blind one’s eyes to the beauty of nature.’

Munden had previously expressed his distaste for the application of lightweight architectural elements like blinds, louvers, and double-glazing to buildings in the tropics, as to him these indicated schemes “which are not suited to the environment and which are thus not good designs.” Instead, he preferred solid building forms given orientations that would limit sun exposure. While he critiqued louvers for obstructing views, Munden

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438 Letter from Roy Munden to Norman Foster, Sept. 9, 1982. F+P Archives, F17724, Client Correspondence, c. Sept. 1982. For more on Admiralty Centre see Wong & Ouyang: Blueprints for Hong Kong, 66.
seemed to more emphatically suggest that a “high tech” solution applied to the glazing problem would stand in the way of an authentic experience of natural beauty. The technical, here in the form of a double-glazed skin, was couched in opposition to the natural. A mirrored glass surface, by contrast, was described as mellowing prospects over the landscape, a naturalized technique already integrated within the urban context of Hong Kong, indeed within the global context of corporate architecture [Fig. 4.20].

Despite ongoing concerns over energy expenditure and maintenance costs for the new building, Munden framed the “technical” and “natural” realms in terms of their aesthetic effects. While Munden’s argument for mirrored glass was based on its perceptual, even symbolic qualities, Foster Associates had the burden of presenting convincing evidence regarding both the technical and the aesthetic performance of the double-glazed solution if they wished to be successful in their campaign against mirrored glass. To maximize the back-up wall’s energy efficiency, they began collaborating with Corning Glass Works to develop a photosensitive glass for the inner skin of the back-up wall. In 1953 Corning had patented photosensitive sodium fluoride glass, which incorporated precise three-dimensional patterns in the form of opaque grids within panes of clear or tinted glass. Louverre glass, which was purpose-designed for HSBC, had opalescent louvers etched within the thickness of each panel to limit the passage of direct sunlight, and an appearance similar to conventional blinds against clear glass when viewed from a distance but greater visibility at close range. The architects developed a

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440 The first mirrored glass curtain wall was developed by Kevin Roche, John Dinkeloo and Anthony Lumsden in the office of Eero Saarinen for the Bell Laboratories building in Holmdel, New Jersey. Roche and Dinkeloo completed the building in 1962 by after Saarinen’s death in 1961. Lumsden, the project architect for the Bell Laboratories, went on to develop other forms of mirrored glass in his Los Angeles practice during the 1960s and 1970s. See Martin, *The Organizational Complex*, 208-211.
new iteration of the sandwiched curtain wall system consisting of a clear pane of 12mm Libbey-Owens-Ford “Tufflex” tempered float glass on the outside face, a 5-mm airspace, and an interior pane of photosensitive Corning Louverre glass, all with double-sealed pressure equalizing joints.

While this double-glazed back-up wall was developed as a solution to the problem of excess heat gain in a fully glazed building, it also answered the architects’ aesthetic concerns. They claimed it would form a diaphanous screen to the outside world, limiting the passage of direct sunlight while softening views. In response to the client’s demand for the “best Bank Building in the world,” Foster Associates insisted that the mirrored glass ubiquitous on tall office buildings provided “a simplistic solution to the energy equation,” offering neither flexibility to respond to unknown future conditions, nor precision for controlled adjustments. By contrast, their proposed envelope would continue to regulate heat gain and brightness whilst maintaining transparency and clear views [Fig. 4.21].

A central design conceit for the headquarters had emerged: how to achieve flexibility and tuneability to regulate heat gain and brightness whilst maintaining transparency and clear views through the glass envelope. Enfolded within this problem were a number of conflicting concerns regarding the performance of the building’s skin. What exactly did “transparency” denote in this context? How far should one be able to see when looking through the windows of the building, and how close to the external

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envelope would an inhabitant need to be to benefit from the views and light it afforded? How would abundant daylight affect interior workspace conditions, and how would the infiltration of solar energy impact air conditioning and ventilation systems? Finally, to what degree would users be able to regulate the relative transparency of this envelope, adjusting both range of vision and interior environmental conditions [Fig. 4.22-4.23]?

The flexibility and tuneability espoused by the architects in defense of the double-glazed skin served as proxies for their conflated technical and aesthetic preoccupations. The terms’ slipperiness was their advantage, for they implied a capacity to respond to any concern—a strategy beyond dispute. Proposing a departure from mirrored glass, the conventional solution for heat and glare control, entailed convincing the client that a distinctive appearance for the new headquarters building would offer commercial benefits. While the energy performance of this envelope could be verified through widely accepted formulae and testing, the visual aspects of its materiality had to be carefully cast. The flexibility and tuneability the architects assigned to this new skin implied a hovering between states, a rhetorical lack of fixity that they could use to their advantage. At the same time, flexibility suggested the capacity to tune individual elements to coordinate with the larger whole of the building, an elaborate assembly of systems.

Roy Munden reported the bank’s concerns that flexibility implied a passive yielding to uncertainty, and insisted that “a bank building in this part of the world must

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443 These concepts were was also applied to space planning, as open offices were deemed a more flexible system than cellular ones, as they could be fine tuned to user needs. See Summary of Meetings, HSPM London Review, Jan. 15, 1982, . F+P Archives, ID 16990, BOX 0202 Client correspondence, Jan. – Nov. 1982.
not give the appearance of fragility.”\textsuperscript{444} Munden argued that only strong, enduring forms could reassure a Chinese people who he claimed were historically accustomed to indeterminacy, but Foster rejected this association of stability with sturdiness. While he was convinced that the new headquarters must impart those “spiritual intangibles of place, culture, stability, "Bank”, “Chinese”, “Hong Kong”, genius loci…,” for Foster flexibility was an aesthetic attribute as much as a pragmatic one.\textsuperscript{445} It stood for both material lightness and fluency with an accelerated global culture, in which the rapid communications driving international business, industry, and finance required expedited responses. As discussions regarding the provision of views over Hong Kong’s harbor became entangled with disputes over how to appraise the headquarters’ appearance, with conflicting analyses of energy efficiency serving to complicate the story, the concepts of tuneability and flexibility allowed the architects to variously qualify technical performance, image, and cost in the design of HSBC’s headquarters.

\textbf{Quantifying Performance}

The notion of tuneability concerned both localized adjustments to the material components of the headquarters’ enclosure, and an interior environment that could be adjusted to suit the requirements of bank employees, computer systems, and building-wide management systems. As such, these precise manipulations to building systems were central to the understanding of the new headquarters as an instrument for profitability. Quantitative means of analysis were pivotal to the way in which the

architects delineated the project’s economy in material, spatial, environmental, and financial terms, and the search for an appropriate method for measuring the back-up wall’s performance became a central concern during the design phase. Solar testing of the Louverre glass was to be carried out in the Phoenix, Arizona laboratory of John Yellott, a mechanical engineer who had developed an expertise in solar energy and the transparency, reflectivity, and transmissivity of glass, and who worked as a glass consultant for projects around the world.\footnote{In the early 1960s, Yellott had helped to devise the solar heat gain factor (SHGF) method of calculating solar heat gain through a specified area of un-shaded clear glass of specified thickness for a given set of conditions. This method was then adopted by the American Society of Heating, Refrigerating, and Air Conditioning Engineers. Jeffrey Cook, “Gentle and Persuasive as the Sun: John I. Yellott 1908-1986,” \textit{Passive Solar Journal, Official Journal of the Passive Systems Division} 4, 3 (1987), 238.}

Immediately following the 1973 oil shock, Yellott was named director of the graduate program in Solar Architecture and Energy Technology at the College of Architecture at Arizona State University.\footnote{“In Memorium: Dr. John Yellott (1908-1986),” \textit{Solar Energy} 38, 6 (1987), 387.} The same year, at UNESCO’s \textit{International Congress on the Sun in the Service of Mankind} in Paris, he presented a paper on ““New Developments in Architectural Glass,” in which he outlined procedures for estimating solar and total heat gains for any location on any date provided that the latitude, time of day, and window orientation are known; these had been adopted by ASHRAE (American Society for Heating, Refrigerating, and Air-Conditioning Engineers).\footnote{John I. Yellott, “New Developments in Architectural Glass,” \textit{International Congress on the Sun in the Service of Mankind} (Paris: UNESCO, 1973), EH 78-2. Yellott defined key concepts such as the solar heat gain factor (SHGF) and the shading coefficient (SC), which is a constant ratio between solar heat gain through any glazing system under a given set of conditions, and the SHGF for the same conditions. To minimize air conditioning cooling loads, the lowest possible SC must be achieved whilst maintaining adequate levels of natural illumination. Ibid., EH. 78-3.} Yellott explained that while ASHRAE procedures for determining heat gain were straightforward for single
glazing, and somewhat more complicated for double glazing, for façade configurations combining single or double glazing with shading devices analytical calculations were less accurate than results from physical tests using solar calorimeters.\textsuperscript{449} For increasingly complex façade configurations, designed to maximize energy efficiency, empirical measurements surpassed theoretical analysis in the evaluation of thermal performance.\textsuperscript{450}

In February and March of 1983, ten years after the UNESCO conference, Yellott commenced solar testing on preliminary samples of Louverre glass. The results of these tests, combined with theoretical analysis by mechanical engineers J. Roger Preston & Partners (JRP), would provide sufficient assessment of the back-up wall’s thermal performance to approve pre-production trials at Corning’s plant in Harrodsburg, Kentucky. Yellott’s testing program proved to be more contentious than anticipated, however, instigating debates regarding suitable methods for calculating solar heat gain and the performance of the envelope, a matter of pressing concern.

In December of 1982, the bank had formed a subcommittee of its board, the Project Policy Co-ordination Committee (PPPC), to oversee management of the new

\textsuperscript{449} Ibid., EH. 78-4 – EH. 78-5.
\textsuperscript{450} Yellott also traced the history of heat-absorbing glass. Early heat-absorbing glasses incorporated minute quantities of iron oxide to increase heat absorbance but visible radiation and glare remained high. The grey, bronze, and black tinted glasses, produced as alternatives to the green iron oxide glass absorbed so much solar heat they reached dangerously high temperatures. In 1963, metallic coated selective-reflective glass was introduced as an effective means of reducing both solar and conduction heat gain by providing high transmittance of shortwave solar radiation, but high reflectance and low transmittance of long wave radiation. By 1973, most metallic coatings were reflective throughout the solar spectrum. According to Yellott, reflective coatings were the only means to maximize thermal resistance for single- or multiple-glazed facades while simultaneously reducing solar gain. While double-glazed windows of bronze and clear glass panes with a metallic coating offered the greatest thermal performance, Yellott doubted the possibility of further reducing total heat gain as long as a substantial degree of visibility was required. Ibid., EH. 78-5 – EH. 78-9.
headquarters project. Losing confidence in the design process, and concerned about a repeat of the steel cost overrun plaguing the project, the bank demanded a technical and financial audit of the project by Pell Frischmann engineers. Due to mounting energy costs, a central focus of this technical assessment was the relationship between the double-glazed curtain wall, the air conditioning system, and interior thermal conditions. The audit forced an expedited testing schedule for the back-up wall and tasked the architects with proving the efficiency of the glazed curtain wall in terms of both cost outlay and future energy consumption, in the process specifying the surface effects essential to its design.

Under threat of value engineering to cheaper mirrored glass, Roy Fleetwood, an architect in Foster Associates’ Hong Kong office who was responsible for the design of the curtain wall, wrote to Norman Foster and Loren Butt in early February 1983, expressing the urgent need to provide more technical performance data on the back-up wall, as well as a viable alternative:

451 Telex re “Back-up Wall,” from Roy Fleetwood to Norman Foster and Loren Butt, Feb. 3, 1983. F+P Archives, ID 17378, BOX 0258, FAHK correspondence, Jan. –July 1983. HSBC contended that the steel contract for the headquarters project was largely responsible for keeping some sections of the UK steel industry alive in 1982 and 1983, and was the largest steel contract, in terms of man-hours, awarded since the construction of the Sydney Harbour Bridge. See “Article on 1 QRC to be sent to all Staff,” 15.

452 Telex from Sandberg to NF, July 14, 1983, re Budget. F+P Archive, F17377, Client correspondence, c. Jan.-Sept. 1983. Sandberg wrote: “The cost of the building, including the bank’s special requirements, excluding fees etc. should not exceed HK dollars 5 billion. I am aware that the quantity surveyors have calculated that the building as presently designed will cost approximately 5.33 billion. This sum includes contingencies and is unacceptable to me and my board. Sums originally set aside for contingencies have already been consumed many times over and I am not prepared to discuss a cost of over 5 billion.” Foster Associates’ 1983 budget proposal of 5.464 billion HK$, excluding management costs, included contingencies of 15 million HK$ for the glazed envelope, 20 million HK$ for structural steelwork, 10 million HK$ each for basement services and modules and risers. See Letter from Levett & Bailey to R Fleetwood and FAHK, June 21, 1983, re Proposed Budget. F+P Archive, F17139 QS Correspondence: , c. Jun. 1983.
Unless we can be more definitive about a fallback and give guidance, we shall be in poor shape to justify our approach either to the auditors or to the board subcommittee, for within the audit period should our development programme on the double glazed option fail to meet its performance target, I fear a reversion to reflective glass in the absence of a clearly defined alternative with known performance characteristics and visual appearance.  

Fleetwood insisted that if upon testing the Corning double-glazed solution failed to meet thermal criteria, the proposed fallback should offer the same “life and spirit” as the three-dimensional, directional quality of the back-up wall. Corning, too, were invested in the successful application of Louverre, offering as a “conciliatory gesture” to refund a pro-rata portion of the material development budget following approval of pre-production samples.

Loren Butt investigated various means of measuring thermal efficiency in order to obtain the most favorable data on the back-up wall scheme. He revised Foster Associates’ initial estimated limit for the solar shading coefficient (SC) of the glazed envelope from 0.325 to 0.45, essentially allowing for higher solar heat gain and tasking the variable

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453 Ibid.
454 Telex, re “External Wall,” from Roy Fleetwood to Loren Butt and Norman Foster, Feb. 8, 1983. F+P Archives, ID 17378, BOX 0258, FAHK correspondence, Jan. –July 1983. He proposed a finely perforated silver-grey blind behind single clear glazing, or alternatively against a background of mirrored glass, as opposed to a shading material laid on the surface of the glass: “I fail to see how any two dimensional decorative application to the glass can meet any relevant architectural criterion in the context of a glazed external wall.”
455 Telex from RJ Mead to JLW, FAHK, L+B, HSPM, April 7, 1983, re PPCC Meeting Decisions. F+P Archive, ID 17378, BOX 0258, FAHK correspondence, Jan. –Jul. 1983. See also Telex from L Butt to R Fleetwood, April 12, 1983, re Corning Back-up Wall. F+P Archive, F17378 Client Correspondence, e. Feb.-Jul. 1983. The additional cost for a pre-production run was 70,000 US$, and Corning offered to refund a proportion of the total 270,000 US$ material budget upon successful conclusion of the pre-production run.
volume HVAC system with additional solar cooling load. In order to accommodate this increased maximum solar coefficient within the overall energy scheme for the building, artificial lighting in the 3.6-meter-deep zone along the perimeter was to be reduced, and the temperature of the constant volume HVAC system lowered by 2°C at all times. But submitted his estimates to Derek Tuddenham, JRP’s lead mechanical engineer on the project, requesting a recalculation of the façade’s solar performance and expressing the urgent need to prove the back-up wall’s thermal efficiency before resuming discussions of its more subjective aspects: “How far we ultimately move towards the new characteristic will depend on several factors, but will be influenced by external appearance and quality of outward views.”

Preliminary tests on the Corning glass performed in Yellott’s Arizona laboratory in February of 1983 demonstrated that in order to improve thermal performance while also resolving issues of glare, tint had to be separated from reflectivity. The tint in the body of the glass would be removed, leaving a clear glass with white bands or louvers to combat heat gain, and a separate anti-glare film would be applied to the inside surface of the Corning glass. This solution, which remained within the costs reported to the bank’s board the previous summer, would mimic the appearance of conventional blinds on clear glass when viewed from a distance, while still providing greater visibility than venetian

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456 According to Butt, variable volume HVAC system would be able to accommodate an additional solar cooling load of 750 watts for every six window modules.
457 This would result in a minimum level of solar cooling load for the constant volume system of approximately 15W/m2 of glass or 360 watts per 6 window modules, a satisfactory level as it would be exceeded on all facades during all normal operating daylight hours. Letter from Loren Butt to Derek Tuddenham at JRP, re “Back-up Wall,” Jan. 5, 1983. F+P Archives, ID 17646, BOX 0274, Foster Associates Correspondence, Jan. 1983.
458 Ibid.
blinds from close up. Upon inspecting a prototype Loren Butt reportedly proclaimed the material to be “‘quite astonishing – ten steps forward’.” HSBC summarily approved the pre-production run of Corning glass, but at no additional cost.

Following an allegation by JRP that the back-up wall produced perimeter cooling loads 20 to 25 percent in excess of specified limits, Foster Associates were anxious to eliminate uncertainty in the performance data. Loren Butt expressed dismay that JRP’s calculations could differ so markedly from Yellott’s tested shading coefficient performance, citing Yellott’s painstaking adjustments to the calorimeter rig as evidence of the extreme precision with which he approached testing and measurement. Yellott had constructed a new calorimeter specifically for the HSBC project; it was designed to measure the shading coefficient of the system comprising half-inch LOF clear float glass and Corning louvered glass separated by a 2.5-inch airspace. The first iteration of the calorimeter had produced flawed results because glazing materials were placed inside the heat-absorbing cavity, causing too much of the solar heat absorbed by the clear glass to be conducted to the cooling surfaces of the apparatus, resulting in unnaturally low temperatures. These results indicated that heat would be conducted into the building

460 “This qualified approval is given out with the separate subject of the objections raised by HSPM and others in regard to the overall design of the back-up wall (which design is not approved hereby).” Telex re “PPCC Meeting Decisions,” from RJ Mead to John Lok Wimpey, Foster Associates Hong Kong, L+B, and HSPM, April 7, 1983. F+P Archives, ID 17378, BOX 0258, Foster Associates Hong Kong Correspondence, Jan. – Jul. 1983.
rather than radiated away from the surface of the glass [Fig. 4.24]. Yellot inserted polystyrene frames to hold the clear glass, eliminating direct contact with the cooled surfaces of the machine. Following this recalibration, shading coefficient values for the double-glazed assembly were estimated to fall within an acceptable range of 0.43 to 0.46 [Fig. 4.25].

Yellott also configured a thermopile pyranometer, similar to the one he had patented in 1968, specifically to test the solar-optical properties of the HSBC back-up wall under real, not simulated, sunlight [Fig. 4.26]. This was used to compare solar transmittance and reflectance for a number of Corning samples, which had varying louver angles in combination with either a tinted or clear body of glass; the transmittance and reflectance were then used to estimate shading coefficient values. Yellott found that while solar incident angle rarely affects shading coefficient values, in the case of

A 12-inch square of the half-inch LOF clear glass was placed together with a 12-inch square of the Corning louvered glass within an apparatus similar to the one Yellott had patented in 1968. The thermopile pyranometer comprised a base plate of aluminum or other metal, upon which were mounted a number of solar cells to electrically measure solar radiation; a milliammeter measured the short-circuit current of the solar cells, and an ampere-hour meter measured the total quantity of solar radiation falling on solar cells in a given time period. A glass dome covered the instrument, rendering it weatherproofed but still able to admit solar rays. See Yellott, J. I. Solar Radiation Measuring Device. US Patent 3,390,576, filed Sept. 28, 1965, and issued July 2, 1968.
louvered glass the incident angle had a significant impact on the material’s solar-optical qualities and shading coefficients. A 20-degree incident angle was determined to produce the optimal results.\(^\text{466}\) Using updated samples that LOF and Corning had sent from production runs dedicated to HSBC, the pyranometer measured average transmittance values of 0.17 for the Louverre and 0.60 for the \(\frac{1}{2}\)-inch LOF clear glass. Using a computer program built specifically for the HSBC project, the shading coefficients for the back-up wall assembly were estimated to be 0.45 for bright, clear sunshine and 0.44 for bright but hazy sunshine.\(^\text{467}\)

While Yellott’s extensive empirical testing appeared to substantiate the energy performance of the backup wall, discrepancies remained between Yellott’s and JRP’s calculations, which emphasized reflection over absorption following the recommendations of the British Chartered Institute of Building Services (CIBS). This, according to Butt, was “a fine academic point, which no engineer in the USA (the biggest air conditioning market in the world) would concern himself about,"\(^\text{468}\) but in order to convince the client of the façade’s viability, Foster Associates had to bring JRP’s calculations in line with Yellott’s. Tweaking the data, they counted marginal influences on thermal gain, like shading effects of structural masts and window mullions, and switching off artificial lights at floor perimeters. Accounting for these effects, JRP conceded that the mechanical system could accommodate the back-up wall, stressing the

\(^{466}\) Ibid., 5. in comparison to 0 or 40 degrees.
“refined” state of their recent calculations [Fig. 4.27]. An attached sketch laid out the performance requirements of the curtain wall assembly: an average solar transmittance for the LOF clear outer pane of 0.60; a mean transmittance of 17% and mean reflectance of 24% for the Corning Louverre glass; and a sealed airspace between the two layers of glass with maximum U-value of 3.85 W/m²°C to be maintained in all seasons. With consensus on thermal performance attained, the next problem was to gauge the impact of brightness, reflectivity, and glare from a transparent envelope upon a workspace composed of rows of computer screens.

Precision Contrived: From the Lab to the Field

While the architects deployed flexibility and tuneability as open-ended terms suggesting the possibility of accommodating an unknown future, precision represented the means of control necessary for the minute adjustments intrinsic to flexibility. In other words, flexibility described a condition, whereas precision denoted the technique for its realization. The aesthetic implications of this technique were central to the interplay between problems of energy and image in debates surrounding the research and

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470 Ibid.
471 Letter re “Air Conditioning and Thermal Performance of Back-Up Wall,” from Derek Tuddenham at JRP to Roy Fleetwood of Foster Associates, July 20, 1983. F+P Archives, F17378, Client Correspondence, c. Feb.-July 1983. JRP contended that the reduced transmittance of clear outer glazing confirmed by Yellott’s tests was a “two-edged sword,” possibly leading to greater use of artificial lights and a resultant rise in cooling load. The fine balance between the daylighting levels permitted by perimeter glazing and the artificial lighting load would therefore have to be reconsidered.
development of HSBC’s glass skin. Although Yellott’s and JRP’s calculations were key to quantifying performance for the Corning Louverre glass façade, a number of other measurements served to define precision for the project. The aims of transparency and environmental regulation underlay the pursuit of precision at HSBC, but they were also symptomatic of a peculiar reflexivity between technological advancement and an array of intersecting interests.

Bruno Latour described a “paradox of development,” in which the further a technological project advances, the less influence technology actually has upon its outcome. His book *Aramis, or the Love of Technology* details a thwarted technological project in which all interested parties take their own contributions as central to its realization. Because managers tend to divide complex technical projects into phases—such as concept, feasibility, modeling, site study, commercial viability, approval, codification, and manufacturing—the project continually oscillates between idea and reality:

> There is obviously no way to contrast the world of technology, which is real and cold, efficient and profitable, with the world of the imagination, which is unreal and hot, fantastic and free, since the engineers, manufacturers, and operators all squabble over the definitions of degrees of reality, feasibility, efficiency, and probability of projects.

Against a linear model of innovation, in which a cohesive initial concept—a stroke of genius—is gradually materialized, Latour presents the “translation model,” in which an initial idea serves primarily to translate the interests of collaborators, who by turns

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473 Ibid., 67-68.
continue to transform the project on its path to completion. While Latour’s main interest in *Aramis* is the interplay of individuals’ visions with the overarching imperatives of efficiency and economy underlying the development of technological projects, the division he presents between the hot world of imagination and the cool world of technique begins to break down when one considers the exaltation of accuracy as both aesthetic tendency and technical expedient. In the case of HSBC, the influence of technology over the outcome of the project was not really diminished as the various parties weighed in, but technical performance was in continual competition with the image of the technological object.

The research and design phases of the HSBC project took place simultaneous to a new approach to sociological analysis by Latour and others that highlighted the pragmatic circumstances of laboratory and scientific practices. Their studies of theoretical and field investigations propounded theories on the impact of fallibility, contingency, and individual interests upon supposedly objective formulations. In a 1982 issue of the journal *Social Studies of Science* dedicated largely to the sociology of technical work in scientific laboratories, Michel Callon and John Law asserted the importance of self-consciousness regarding the impact that the act of sociological analysis, the “construction, consolidation, erosion and destruction of social worlds and their components,” has upon the dynamic complexity of intersecting interests in scientific practices. In their subsequent introduction to *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World*, Callon, Law, and Arie Rip aimed to

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474 Ibid., 119.
expose the frequently obscured political nature of scientific objects and texts, insofar as these implement social transformation. Scientific texts, or “inscriptions,” the authors claimed, operate as political tools by allowing scientists to inform and influence those outside their immediate purview. As such, they may be viewed as actors or propelling forces within the network of interests constituting scientific practice, whose very structure was subject to the influence of numerous typically covert factors.

For John Law, one major contribution of the scientific laboratory, where it exercises considerable power, is its capacity to correlate entities that are typically seen as disparate, such as natural phenomena, people, and social institutions, through the act of inscription. Law terms the construction of a technological system “heterogenous engineering,” in that it juxtaposes varied and often contrary components—social, natural, or technological—within a newly stable network. The stability of this network depends upon a standard lexicon to address technical, natural, scientific, social, political, and economic forces on the same terms.

It might be said that the preoccupation with precision linked and stabilized the networked forces involved in composing the HSBC headquarters’ façade. Made evident throughout various forms of representation or inscription—sketches, detail drawings,

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479 Law calls this interdependence of the social with the other lines of a network “generalized symmetry.” Ibid., 123.
testing reports, charts and diagrams, performance criteria, physical models, mockups, and production requirements—this impulse towards precision gained traction as the project moved between theoretical analyses and field studies, or between idea and reality. If we consider the engineers, architects, and consultants involved in the research, design, and production of the headquarters’ glazed curtain wall as equal collaborators in the production of the technological object through the attendant standards, codes, budgets, tests, and aforementioned modes of inscription, then we can begin to see how aesthetic purport became imbricated with the more utilitarian constraints imposed upon the object. Indeed, precision was continually redefined and negotiated with each successive drawing, prototype, calculation, and test.

While the primacy of precision in the design of HSBC’s envelope was coincident with a more general contemporary shift in the sciences towards more accurate and often computerized analyses, at the same time there was a constant need for “field analysis,” in the form of mock-ups and prototypes, to confirm predictions and hypotheses of performance under actual physical conditions. One element of the design and testing process that caused particular vexation in the negotiation of precision was the margin of tolerance. Here, disputes arose over when exactly stipulations of precision exceeded necessity, which tests and representations were most accurate, and which best denoted the accuracy of the system being evaluated.

To achieve the most precise manufacture and erection tolerances on the 275,661 sq. ft. curtain wall, Cupples teamed with McDonnell-Douglas, a St. Louis, Missouri based enterprise with expertise in aircraft and military technologies, who provided powerful computers for detailed structural calculations, as well as facilities dedicated to
research on the most meticulous manufacturing and tooling methods [Fig. 4.28-4.29].

With a saw obtained through McDonnell-Douglass, Cupples were able to achieve a level of accuracy of ± 1/5000 mm, an exactitude impossible to attain using any other cutting machine, and well within the specified tolerance of ± 1/8 inch on each panel. Mock-ups produced by Cupples were subject to a battery of standardized tests to check static air pressure air and water infiltration, dynamic pressure water infiltration, and static pressure structural performance [Fig. 4.30]. The Florida-based Construction Research Laboratory, a leading facility in curtain wall performance analysis, conducted the tests at Cupples’ St. Louis production facility, in accordance with the ASTM and AAMA (American Architectural Manufacturers Association) requirements for testing procedures, and confirmed adherence to performance specifications for the job. To guarantee accuracy in on-site assembly, Cupples proposed to erect a 3-storey mockup in St. Louis to train American field supervisors to perfectly install all components of the curtain wall and cladding systems. Five American-educated Chinese engineers were also to be trained at construction sites in the United States and certified as field supervisors. The mockup

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480 Cupples Products, Updated Proposal for WP 5100, Second Draft, Aug. 6-13, 1981. F+P Archives, R29758. Cupples’ 1981 proposal for the HSBC job listed a number of standards of performance in addition to tolerances, including: provision for thermal or building movements; prevention of water penetration and air leakage; minimizing deflections of framing members; limits for shading coefficient as well as light and thermal transmittance values; procedures for the construction and testing of mock-ups in line with performance criteria set by the American Society for Testing and Materials (ASTM); hardness criteria for setting blocks, edge blocks, and spacers supporting glass panels; material characteristics of sealing and glazing compounds; requirements for manufacturing methods; and training in construction techniques.


would then be shipped to Hong Kong, where the supervisors would train a team of 75 local construction workers in the American methods [Fig. 4.31-4.32].

Inevitably, there were conflicts between the high precision manufacturing methods employed, Cupples’ production standards, and the various quality surveillance techniques pursued. While Cupples draftsmen used a convention of dimensioning detail drawings to 1/64th of an inch, this was merely to indicate to the production plant that a close tolerance was required, while in actuality the company accepted that the dimension of any member in the façade assembly could vary by as much as 1/16th of an inch without having any measurable effect on the building as a whole. The quality assurance inspectors for the HSBC job, Gilbert Commonwealth engineers, could only judge production accuracy based on the drawings they were given, thus leading them to reject most of the work. Cupples, who had not worked with quality assurance inspectors on any previous projects, complained that Gilbert Commonwealth were unfamiliar with the manufacturing processes of the cladding industry, and not “product oriented,” creating an impasse between the desire for accuracy as reflected in the approved dimensional tolerances, and the actual means of production required to achieve such. For Cupples, the quality assurance inspectors were obstructing the customary path from idea to reality.

Meanwhile, Foster Associates remained concerned about Cupples’ ability to meet both

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485 Ibid.
tolerance and visual standards in their mock-ups and prototypes, and sought the best method of quality surveillance to ensure that components would fit together properly on site. Cupples challenged the practicality, and the necessity, of the accuracy standards that Foster Associates insisted upon. Despite the fact that they had altered their manufacturing methods to achieve a 50% improvement in quality over all previous work, Cupples were unable to commit to realizing the level of precision that the architects specified. From their perspective, “dimensional problems could be overcome but the main problem area is aesthetics.”

Discord had arisen not only regarding the correct means of achieving erection tolerances, but also how to precisely specify them, and this had everything to do with visual analysis. Cupples’ job proposal had stated that the “maximum offset from true alignment between two identical members abutting end to end in line” was to be 1/16 inch. Within the context of the façade assembly, Foster Associates and contractors John Lok/Wimpey understood the term “abut” to refer to “two or more adjacent components erected in the field and the resulting visual alignment (to a maximum of one sixteenth of an inch).” Manufacturing tolerances could not be aggregated with erection tolerances, so they rejected as visually unacceptable a prototype in which sill rails and mullions were misaligned by over 1/16\textsuperscript{th} of an inch, and another in which corners varying ± 1/16\textsuperscript{th} of an inch were permissible, but the bowing of the sides in addition to this

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\textsuperscript{487} Ibid.
\textsuperscript{488} Ibid., 19. All parts of the curtain wall were to remain within a maximum variation of 1/8 inch per 12 feet of length, or ½ inch in total length from any plane or location shown on approved shop drawings. See Cupples Products, Updated Proposal for WP 5100, Second Draft, Aug. 6-13, 1981. F+P Archives, R29758.
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misalignment was not. The tolerances exhibited in Cupples’ early prototypes exceeded the architects’ interpretation of the maximum specified values, which was as much visual as quantifiable. Cupples, still in the midst of installing new and more accurate machinery, requested that completed units be inspected for tolerance compliance, rather than individual components. Foster Associates rejected this proposal as too risky, however, since whole assemblies could be rejected based on one flawed component; the architects insisted that “the system would not be designed the way it is if such tolerances were not required.”

Here was a problem of inscription. Specifications outlined one understanding of tolerance, but mock-ups and prototypes urged a different definition, complicating the discussion. There was no standard lexicon to reconcile inconsistent depictions of tolerance between the multiple forms of inscription and the various parties who produced them. The hot world of imagination confronted the cool world of technique, and quantitative assessment was unable to match the architects’ exacting visual standards. If the development of the curtain wall was a form of heterogeneous engineering, commingling technological, environmental, and aesthetic imperatives, then the dispute over tolerance demonstrated the need for consensus to achieve a stable new model of enclosure.

Between the Window and the Screen

While the resolution of construction tolerances and solar performance for HSBC’s curtain wall relied upon material precision, the glazed envelope was also constituent of a novel

\[490\] Ibid.
interior workspace defined by large numbers of computer workstations and computerized building systems, an environment which demanded precise regulation. Following Daniel Bell’s prognostications of an information-driven economy, during the late 1970s and early 1980s there was increasing interest in the ways computing, telecommunications, and manufacture with microtechnology might impact building design. Throughout the early 1980s Architects’ Journal published several articles on the installation of computer systems, communications networks, and computerized building management systems within existing buildings. An examination of one of fifteen pilot projects by Britain’s Department of Industry to demonstrate information technology in use showed the arrangement of networked Xerox computer workstations across two floors of London’s County Hall building, as part of an effort to aid the collection of research and issuing of reports by the Greater London Council’s Scientific Branch. At stake here was both a concern for the practical spatial and productivity implications of the automated workspace, but also a fascination with the presence of the machine itself in the office, laboratory, bank, home, or school. Images showed various screen configurations; juxtapositions of computers and traditional workspaces; and the mismatch between futuristic communications networks and the conventional buildings in which they were

493 “The Appliance of Science,” Architects’ Journal 176.48 (Dec. 1, 1982), 50-54. The GLC’s Scientific Branch which issued technical recommendations on issues like hazardous waste disposal, noise and air pollution, and fire safety.
often housed [Fig. 4.33-4.34]. The August 25, 1982 issue of *Architects’ Journal*, devoted to “The Architect and Information Technology,” attempted to come to terms with data processors, telexes, electronic mailboxes, and ‘intelligent machines’ as they would affect urban, domestic, and office space, and examined the near future of architectural design, imagining a world five or ten years hence. The issue addressed technical problems such as the accommodation of computer terminals—known as visual display units or VDUs—in office spaces, as well as broader and more ominous provocations: “Quietly, unambiguously, the increasing power of information technology is dissolving the institutions that hold conventional society together.”\(^{494}\) An article entitled “Banking: Containing the Costs” examined the particular appeal of information technology for the banking industry. Attributable in part to the large volumes of paper used for information processing, as well as increased volatility in interest and exchange rates during the period, banks looked to information technology to improve efficiency and increase revenues. More VDUs per employee would speed calculations and reduce paper consumption, resulting in a more efficient business model, although in large number these workstations engendered new thermal and optical conditions, prompting a number of studies dedicated to ergonomics and environmental design in the computerized workplace [Fig. 4.35].\(^{495}\)

Concurrent with research on spatial configurations of computer workstations and networked communications systems, and simultaneous to the design development of


HSBC, there were a number of British and American studies to assess the “physical and emotional ailments” associated with workers’ computer usage in automated office environments, such as orthopedic problems, eyestrain, headaches, indoor pollution and respiratory problems, sensory deprivation, irritability, and depression [Fig. 4.36]. In the early 1980s, legislation was proposed in twelve US states to regulate the use of VDUs, recommending measures like mandatory eye exams and adjustable furniture, and the US House of Representatives subcommittee on health and safety undertook a study of computer-related health hazards to determine whether there was need for federal action. The American National Standards Institute also developed guidelines on VDU operator safety to be issued in 1985. Responding to this fixation with the physiological and psychological effects of the electronic office, the Whitney Library of Design produced a guide for designing the automated office, which addressed such concerns as radiation hazards, vision disruption, ergonomics, and stress associated with computer workstations [Fig. 4.37].

Of central concern were glare, reflections of direct lighting on computer screens, and the conflicting lighting conditions recommended for conventional paper office work versus computer screen work, requiring constant readjustment of the eyes. Following a

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497 Dietsch, 161-163.

study of over 4,000 office workers, the Buffalo Organization for Social and Technological Innovation (BOSTI) estimated that effective office design, with adequate furniture and lighting, would save $1600-$1700 per year for each manager or professional employee.\textsuperscript{499} Given these projected cost savings, a number of studies were dedicated to the subjective experience of the user as well as the effects of environment on worker productivity. A study at the University of Colorado at Boulder, funded by the Peerless Electric Company, used people’s subjective evaluations of computer simulations to determine that indirect lighting would create a more agreeable atmosphere for workers using VDU terminals.\textsuperscript{500} [Fig. 4.38-4.39] Research was dedicated to various means for controlling screen reflections and glare, such as parabolic louvers over ceiling-mounted fluorescent lights to produce indirect light, or fiberglass mesh blinds coated with Mylar on the outside face to reflect daylight away from the building. More localized recommendations included screens with black text on a white background to mimic the printed page, instead of the then predominant green-on-black screens, or polarizing filters installed atop existing VDU screens [Fig 4.40].\textsuperscript{501}

In an article entitled “Creature Comforts in the Computer Workspace,” published in \textit{Architecture California} in July of 1985, Jain Malkin, an interior designer and space planner active in California’s growing computer industry, laid out a number of strategies to mitigate the stresses induced by the VDUs and other computer hardware that had

\textsuperscript{499} Dietsch, 162-163.
\textsuperscript{501} Dietsch, 165.
“invaded the work surface” in the electronic office.\textsuperscript{502} Primary among her recommendations were techniques to reduce illumination levels and glare, such as adjustable window blinds and the application of dark vertical and horizontal surfaces behind the user to reduce reflections, as well as moving light fixtures outside the “mirror zone” to avoid visible “fixture ghosts” on VDU screens.\textsuperscript{503} Despite such technical measures, Malkin argued, architects could not ignore the office worker’s subjective evaluation of a space, and she described a corporate headquarters office project she had worked on, in which all word processors were positioned in a prime corner space with floor-to-ceiling glass walls facing north and west, with panoramic views of ocean and city center. Despite the standard fluorescent lighting fixtures and lack of task lights, which, combined with the glare from natural light, constituted a condition that all research on computer usage would have recommended against, the word processing staff reported complete satisfaction with their working environment. According to Malkin, “This can only be explained as the triumph of psychology over physiology. That corner space with its incredible view carried with it a status so powerful that the staff was unaware of the common complaints of VDT users.”\textsuperscript{504} For Malkin, conventional research on the design of computerized offices disregarded the aesthetic experience of work environments.

The change in workspace configuration brought on by the introduction of computers engendered a new discourse on interior environments. One architect who participated in a survey on workspace by the US federal government described it

\textsuperscript{502} Jain Malkin, “Creature Comforts in the Computer Workspace,” 32. Malkin also taught medical space planning at Harvard’s Graduate School of Design.
\textsuperscript{503} Ibid., 34.
\textsuperscript{504} Ibid., 35. Malkin uses VDT (video display terminal) in place of VDU.
thus: “The advent of automation has heightened client awareness of the environment. It is as if the intensity which the VDT imposes on the participants requires an immediate antidote that must be provided by the space around them.”505 In the case of HSBC, the number of VDUs planned for office spaces meant that the desire for a glazed-skin transparent building with expansive perspectives over the landscape faced off against the inevitable glassy reflectivity emanating from rows of computer screens. The interaction between these vitreous surfaces was at the time still indeterminate, leading to dissonant evaluations of potential effects upon office workers’ perception and productivity.

In late 1981, Austrian lighting research and engineering firm Bartenbach and Wagner were employed as consultants on the HSBC project in order to assist mechanical engineers JRP in the design and calculation of natural and artificial lighting systems. Bartenbach and Wagner, based in Innsbruck, were proprietors of a number of unique testing apparatuses, including the world’s largest “artificial sky,” a domed testing chamber fitted with hundreds of computer-controlled luminaires to simulate any natural lighting condition [Fig. 4.41]. They were appointed to collaborate on the design of the banking hall atrium, a void at the center of the HSBC tower intended to funnel light to office spaces and down to the plaza beneath the building, as well as to analyze the workspace lighting conditions produced by the HSBC’s glazed curtain wall in relation to the large numbers of VDUs planned for the offices.

In January of 1982 Bartenbach and Wagner submitted to Foster Associates a report entitled “Visual Performance at VDU task areas in Relation to Office Environment

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505 Dietsch, 166.
This study was intended to optimize the visual conditions of office work, specifically in situations where VDUs would be positioned near exterior glazing, the condition in the majority of office spaces in the new headquarters. Using the artificial sky and a 1:10 scale model of a typical office space, the study evaluated the effects of window luminance on VDU screens from six combinations of reflective or clear glass with perforated or opaque blinds in white or grey, or vertical louvers, plus one sample of clear glass with a sunlight diverting prism. Taking into account overcast sky conditions compared to clear skies with varying sun positions and room orientations, the study assessed effective illumination levels of the interior space at a working plane height of 0.85m above floor level, and at distances 1, 5, and 10 meters from the perimeter glazing [Fig. 4.42-4.44]. The study also compared the effects of window luminances (in candelas per square meter, cd/m²) from the seven glazing and blind combinations being tested upon the reflections and disturbance values measured on VDU screens, which Bartenbach and Wagner had determined were not to exceed 225 cd/m² [Fig. 4.45-4.47]. and Wagner concluded that all combinations of clear or reflective glass with opaque or perforated louvers produced too much luminance for VDU work, and argued that only reflective glass offering a mere 6% daylight transmission, combined with adjustable vertical louvers, or clear glass with a layer of adjustable prism glass behind, would achieve adequate brightness control with the requisite visibility and psychological contact with the outside world [Fig. 4.48].

These suggestions directly opposed Foster Associates’ vision for HSBC’s office spaces and they rejected the appearance of reflective glass and vertical louvers, which

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awkwardly interrupted views out of the building. Moreover, Bartenbach and Wagner’s recommendations would result in a relatively dark interior, quite distinct from the open, light-filled spaces shown in depictions of the project [Fig. 4.49-4.50]. The client, however, remained concerned about limiting energy costs and maximizing productivity by shielding against direct sunlight. The contest between mirrored glass and a double-glazed system persisted, pitting metrics of energy efficiency against predilections for transparency.\(^{507}\)

In April 1983 Foster Associates commissioned Friedrich Wagner to test a sample of the Corning Louverre glass, in conjunction with a pane of 12mm clear glass, for solar transmission and surface brightness values. Wagner reported a level of 2900 candelas under bright sunlight conditions, and 420 candelas for bright but diffuse light conditions. These far exceeded his recommended limit of 225 candelas per square meter, a criterion that Loren Butt critiqued as “virtually impossible if any reasonable outward views are to be achieved…”\(^{508}\) Wagner’s main concern was ways in which daylight brightness might interfere with computer terminal usage in office spaces. Butt, however, likened Wagner’s stringent standard to a windowless office situation, arguing, “we are only going to be able to judge the brightness/VDU performance subjectively, which means setting up the back-up wall in a proper full scale mock-up in HK.”\(^{509}\) The primary mechanical engineer on

\(^{509}\) Ibid. This mock-up was already planned, provided Corning could produce enough samples of the Louverre glass in a pre-production run. This as at the request of the client, to reveal information not readily visible in prior models made by the architects. See Telex from Roy Fleetwood to Loren Butt, re “Draft of PPCC Paper on External Wall,” Feb. 23, 1983. F+P Archives, ID 17378, BOX 0258, FAHK correspondence, Jan. - July 1983.
the project recommended subjective, visual testing as the best means of settling questions of performance. Moreover, he accepted “the VDU limitations of the Corning glass,” and was unprepared to consider an alternative solution.\textsuperscript{510} Image had reemerged as the foremost consideration, a shift reinforced by the client’s response to the Hong Kong mockup.

“Seeing the Rocks on the Hills”

Consensus regarding the need for a mock-up suggested that the convergence of extensive glazing, VDU terminals, artificial lighting, and automated air conditioning produced a model of environment that required a multipronged form of analysis, simultaneously precise and subjective. To achieve a compromise between thermal control and the best possible glare-free views out of the new headquarters building at all times of day and throughout the year, the architects and mechanical engineers demanded accurate data on typical meteorological and solar conditions to calculate predictions of what Butt called the “likely behaviour and visual appearance” of necessary adaptations to the façade, such as the position or angle of louvers, or the degree of glass tint.\textsuperscript{511} These figures were intended to provide an exact representation of performance, which could then be evaluated relative to more elusive perceptual criteria like transparency and range of vision.


Conversely, Loren Butt suggested simultaneously subjective and empirical means of evaluation to determine just how airtight the double-glazed façade should be. The back-up wall’s outer layer of glass acted much like a suspended screen, with gaps at the top and bottom to allow the passage of air and moisture, but mechanical systems consultants JRP had proposed that these gaps be sealed to improve the back-up wall’s U-value. Concerned that sealing the airspace could lead to condensation within the cavity if the seal were “nearly perfect, but not actually perfect,” Butt recommended testing a range of gap sizes to determine which would in fact be technically acceptable.

Acknowledging that there was no reliable scientific method for calculating the appropriate width of each gap, Butt advised: “Making it look reasonable is the first step, and the next would be to test it…” While elsewhere the visual operated to reconcile thermal performance with the aesthetic purpose of the building, here it served as the starting point for empirical testing.

In addition to mock-ups of fragments of the glazed façade, the client requested a mock-up of an entire section through a typical office space. This was intended to better illustrate the “internal concept” as it would be realized through such elements as perimeter glazing, air conditioning, ceiling and lighting systems, floor outlets, partitions,

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513 Memo from Loren Butt to Gordon Graham and Norman Foster, Aug 4, 1983. F+P Archives, F17380, Client Correspondence, c. Jan.–Aug. 1983. Butt suggested that testing could be performed at the Building Services Research and Information Association (BSRIA) in Bracknell, UK. BSRIA is a research and consultancy organization providing specialist services in testing and instruments related to the construction and building services industries.
and workstations, etc.\textsuperscript{515} The complete environmental system, which the architects described as a flexible assembly of components able to be fine-tuned for maximal accuracy, was subject to quantification—as in Butt’s and JRP’s aforementioned cooling load calculations—and, at the same time, to the very personal judgments of the HSBC’s chairman, board, and managers. Ultimately, purportedly objective computations of the headquarters’ thermal performance were pitted against subjective and idiosyncratic perspectives on how best to maximize productivity in a contemporary bank.

By mid-August of 1983, the mock-up of the Corning glass back-up wall had been erected on Tsing Yi Island in Hong Kong to be inspected by Chairman Sandberg, who promptly dismissed the configuration as unsuitable due to the optics of the Louverre glass, which he claimed would constrain prospects over the surrounding landscape. Sandberg demanded that the architects formulate alternative solutions.\textsuperscript{516} He dispatched bank board member Norman Thompson to the London offices of Foster Associates to assess the progress of the design, where Norman Foster did his best to convince the client that while the previous mockup had been hastily assembled for informational rather than visual purposes, the new one looked vastly superior, demonstrating characteristics that would be unique to the building. Thompson retorted that the future inhabitants of the building, rather than the architects, would determine the best material for its envelope.


They wanted to “see the rocks on the hills” of the surrounding islands, and if they felt the glazing restricted their views, then “you could sense what was going to happen.”

The architects were aware that presenting a mockup to the client posed some risks. Foster explained in a telex to Roy Fleetwood:

Most buildings emanate like rabbits out of a conjuror’s hat. It is virtually unknown to have any hint of the emerging reality through advance glimpses of, say, even models let alone full size mock-ups or prototypes. In such an approach the final end product – a building – is quite literally a surprise package – and that is normal.

For the headquarters project, the architects had established a working model that they termed “fast track design development,” in which construction is begun before all elements of the building have been finally designed. This was one reason why the dispute over the building’s final cost arose during the construction process, as both pricing and overall cost estimates continued to change with each modification of the project’s design. Another aspect of fast track design development was the involvement of designers, engineers, consultants, and client in discussions through the use of models, mockups, and prototypes. Foster made clear to Fleetwood that this method of viewing parts of the building separate from the context of the whole, and prior to their finalized design,

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517 Notes of Meeting Held in Foster Associates Offices on Sept. 19, 1983. F+P Archives, ID 17377, BOX 0258 Norman Foster correspondence c. Jan. – Sept. 1983. RA Guy, project manager with the Hong Kong Shanghai Property Management group, had also insisted upon maximum visibility on the north side of the building, across Statue Square and over the harbor: “We require the maximum downward vision possible, the only impingement on this should be the exposed area of the individual sun shield blades.” Letter from RA Guy, to Foster Associates Hong Kong (attn Graham Phillips), April 11, 1981, regarding sun shading on main bldg.


519 Article on 1 QRC to be sent to all Staff, sent from RV Munden to JRP Breen, Jan. 18, 1984. F+P Archives, R34548 FAL, FAHK, HSBC Correspondence Package no. 3760 3(a), “Hong Kong Mock Up Supply of Labour only for Installation of Mockup Curtain Wall Sub-contract, c. Mar. 1984.”
required the architects to instill trust in the client, imparting “visual enthusiasm” for mockup components that still left much to the imagination. For his part, Foster maintained that the louvered glass back-up wall offered incomparable vistas over Hong Kong: “The strength of our back-up wall is that it transforms the view – do you believe that? I hope so. It looks great.”

While Norman Foster endeavored to persuade Sandberg that, beyond being a “technically elegant solution,” the Corning wall also created a “beautiful and luminously subtle back drop,” Loren Butt worked to formulate three alternative façade compositions, all of which left the 12mm outer skin of clear glazing unchanged. The first incorporated perforated metal blinds by Japanese manufacturer Nichibei between the outer and inner panes of glass and replaced the Corning glass with 6mm-thick tinted glass panes. The second replaced the Corning glass with a pane of reflective glass, which would of course produce a mirrored building, but “not quite as brittle as Admiralty,” according to Butt, because of the outer layer of clear glass. The third option replaced the Corning glass with a clear double glass element, producing a triple-glazed façade, with an additional airspace and re-radiation heat shield. Sandberg requested that full-scale...
mock-ups of all three alternatives be constructed for viewing by mid-September, 1983 to permit “objective comparisons” of the options.\textsuperscript{523}

As Foster Associates rethought the optics of the back-up wall with Sandberg and others at HSBC, John Yellott continued working in his Phoenix laboratory to refine the performance of the Corning glass, seeking a workable compromise between expanded views over the surrounding landscape and control of thermal gain. Spurred by Sandberg’s visual preoccupations, Yellott tinkered with the louver angles, using pyranometer tests to see how minute adjustments would affect the shading coefficient of the material. His reports showed that switching from the previously prescribed 20-degree downward-tilted louvers to horizontal louvers, thereby improving visibility, would produce a small increase in shading coefficient, from 0.44 to 0.4536, diminishing solar performance. A more subtle adjustment to a 10-degree louver tilt, however, resulted in only a negligible rise in shading coefficient value, thereby achieving a more feasible adjustment to outward views.\textsuperscript{524}


\textsuperscript{524} John I. Yellott and David B. Tait, “Solar Optical properties of Samples of ‘Louverre’ Glass with Louvers Tilted at 0 and 10 Degrees; Shading Coefficients and U-Values for these Samples in the Hong Kong Configuration,” Corning Glass Works Report No. 8303-3 (Phoenix, AZ: Yellott Solar Energy Laboratory, August 19, 1983), 3. Yellott also explained that shading coefficient values were relatively high for the back-up wall configuration due to the high solar transmittance of the outer pane of clear glass, forcing the Louverre glass to absorb a large degree of incident radiation. Moving the Louverre to the outside pane, and placing the clear glass on the interior, would significantly enhance the performance of the façade. See John I. Yellott and David B. Tait. “Shading Coefficient and U-Value for ‘Louverre’ Glass Alone; Shading Coefficient and U-Value for ‘Louverre’ Glass as the Inner Light and Clear ¼ in. Float Glass as the Outer Light in a Double-Glazed Window,” Corning Glass Works Report No. 8303-5. (Phoenix, AZ: Yellott Solar Energy Laboratory, Sept. 2, 1983, 2-3.
Due to Corning’s delays in producing samples of alternative glass types, the architects began to present various alternatives, such as combining Louverre glass with venetian blinds.\textsuperscript{525} Foster was reminded that bank employees and executives absolutely needed to see “the rocks on the hills.”\textsuperscript{526} Given Chairman Sandberg’s demand that venetian blinds be down at all times, and arguing that the blind grid would compete against the horizontal grid of the Corning back-up wall, producing “visual clutter,” Roy Fleetwood argued that using blinds alone would be preferable to combining them with the Louverre.\textsuperscript{527}

By January 1984 the Bank had approved the alternative façade composition with a gasket-sealed clear toughened glass outer skin, a tinted glass back-up wall to offset heat gain, and motorized perforated Nichibei silver blinds positioned between the two layers of glass to further deflect sunlight [Fig. 4.51-4.52]. This option would achieve the desired performance criteria and offered projected savings of around 20 million HK$ over the Louverre option.\textsuperscript{528} A letter to be sent to all HSBC staff, justifying the building’s convoluted design process, described the new headquarters as having a double-glazed

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\item[527] Telex re “External/Internal Gridding,” from R Fleetwood to Norman Foster, c. Nov. 4. 1983. F+P Archives, ID 17387, BOX 0258, FAHK Correspondence, Aug. 1983. Fleetwood continued: “The blinds themselves will look fine and, in my view, the right design decision has been made. My view would be different if the blinds were up most of the time when the horizontal gridding on the glass enhances the design and I told the chairman this.”
\item[528] Article on 1 QRC to be sent to all Staff, sent from Roy V. Munden to JRP Breen, Jan. 18, 1984. F+P Archives, F22167 Client Correspondence, c. Jan.-Nov. 1984. \textsuperscript{528} See also Telex from L Butt to R Fleetwood, Aug. 18, 1983, re External Wall. F+P Archive, ID 17387, BOX 0258 FAHK Correspondence, Aug. 1983.] See also Memo from Anthony Hackett of FA to Gordon Graham, June 25, 1982, re “HSBC External Wall, A Brief Resume.” F+P Archive, ID 17949, BOX 0331, General FA Correspondence.
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façade, with one lightly tinted layer to offset heat gain. Perforated blinds by Japanese manufacturer Nichibei positioned between the two layers of glass would further deflect sunlight, while the perforations would still permit views out of the building when they were drawn, “giving a gentle, ‘lace-curtain’ effect.” Foster Associates contended that the perforated blinds upheld the building’s “visual integrity” while being even easier and more cost effective to maintain than the abandoned Corning Louverre back-up wall [Fig. 4.53].

Beyond providing the building’s face or image, the Bank sought an envelope that functioned spatially and technologically to stimulate profitable output [Fig. 4.54-4.55]. As part of an environmental system that the architects described as a flexible assembly of components, the Nichibei blinds offered tuneability for accurate environmental management. The blinds could be manipulated locally or operated through the computerized building management system by Johnson Controls. This system was

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529 Article on 1 QRC to be sent to all Staff, sent from Roy V. Munden to JRP Breen, Jan. 18, 1984. F+P Archives, F22167 Client Correspondence, c. Jan.-Nov. 1984.
530 Letter re “Venetian Blinds,” from Roy Fleetwood of Foster Associates to R. Watts of HSBC, Feb. 14, 1984. F+P Archives, F22167, Client Correspondence, c. Jan.-Nov. 1984. Fleetwood wrote: “The design of the blind is unconventional, but builds upon principles which have been individually tried before to overcome the imposed constraints of other elements already manufactured or designed.”
planned to regulate lighting, air conditioning, and all other services, “to ensure the environment remains constant, whatever changes take place outside or whenever heat-generating equipment is moved or installed.” In addition to visual integrity, therefore, ‘environmental constancy’ had emerged as a major objective in the new headquarters’ design, both to maximize cost efficiency but also to ensure a productive and profitable workspace.

**Productivity and Environmental Management**

The history of modern subjectivity is of course inextricably linked to the figure of the productive laborer, and the modern interior has frequently been construed as a mechanism for regulating productive bodies. Under the ideology of productivism, ergonomics cast the human body as a converter of energy into product, transmuting the representation of work into the actual process of work itself. By the early 1980s the widespread computerization of work processes and developments in telecommunications

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533 Article on 1 QRC to be sent to all Staff, sent from Roy V. Munden to JRP Breen, Jan. 18, 1984. F+P Archives, F22167 Client Correspondence, c. Jan.-Nov. 1984.


and information processing had altered production in several important ways. First, new financial models and analytical tools were needed to represent and transmit processes of capital exchange in an increasingly abstract risk-based global market. Second, a surge in expedited trading patterns made possible by computers, and the advent of digitized worldwide communications in the financial sector and beyond, meant a wholly new workspace environment. Third, the constitution of this environment relied upon a series of discursive and metric techniques, technologies of representation and inscription, which prescribed new standards and methods of environmental management to maximize productivity for the laboring bodies within.

The 1982 ORBIT study, for Office Research on Buildings and Information Technology, which HSBC’s property management group used as a resource in the planning of the new headquarters, was intended to provide an analysis of the material, spatial and social implications of information technology in the workplace [Fig.4.56]. Sponsored by ten different parties from the UK’s construction, real estate development, and furniture industries, as well as by the British Department of Industry, British Telecom, and three Scottish new towns, the ORBIT study focused upon the intersection of computerization with organizational structure and design. London-based architects and planners DEGW, who had developed an expertise in space planning for offices,

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This shift began in the early 1970s, when the switch to floating foreign exchange rates accompanying the collapse of the Bretton Woods agreement resulted in greater volatility within the currency market. At the same time, the formation of the Chicago Board of Trade Options Exchange in 1973 introduced option trading within major financial markets, which soon led to financial derivative trading and a rapidly expanding market in foreign exchange based on derivatives formed from currency rates. See M.A.H. Dempster, ed., *Risk Management: Value at Risk and Beyond* (Cambridge; New York: Cambridge University Press, 2002), and Michel Crouhy, Dan Galai, and Robert Mark. *Risk Management* (New York: McGraw Hill, 2000).
conducted the study in association with office automation and telecommunications consultants EOSYS and design researchers Building Use Studies. DEGW partner Francis Duffy led the study, which culminated in a report that enumerated changes projected for the use of office space in coming years. Arguing that a large portion of the telecommunications technologies likely to affect office design over the subsequent decade was already available and in use, the report predicted a threefold increase in the number of office workers who would be allocated “electronic workstations” over the next ten years, with a far more drastic upsurge in computer usage in the finance industry [Fig. 4.57-4.58].

The study recommended four “criteria of performance” to support the merging of computers and telecommunications in office space: “capacity” for new technologies; “adaptability” to change space; “buildability,” or the ease of carrying out changes; and “manageability,” or efficient daily building operations and maintenance. HSBC touted the genius of Foster Associates’ anticipation of these criteria in their design, with such components as moveable floors hung from the structure, the elimination of interior columns to create a 50% increase in usable floor space, raised flooring to ease changes to

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537 DEGW was established in London in 1973 by Frank Duffy, Peter Eley, Luigi Giffone and John Worthington. The practice focused on design and management of the office workspace.

538 Francis Duffy, Information Technology and Office Design: the Orbit Study (London: Orbit, 1983). This evolution of workspace requirements was placed within the context of a steady growth in the white-collar workforce, quantity of office space, and tertiary sector of the economy that had taken place in the UK since 1900, Ibid., 12.

539 Ibid., 4, 30. The ORBIT study quotes the EOSYS Delphi Forecast research on rates of introduction of information technology predicted by managers of 50 large UK companies, which found that multi-task workstations were expected for one in six office workers within 5-10 years. For the finance industry, one workstation was predicted for every six employees within 5 yrs, with many companies already exceeding that level of use.

540 Ibid., 5.
ducting, moveable electric and air conditioning outlets, and an interior environment modulated by a double-glazed skin and computer-controlled building management system [Fig. 4.59-4.60]. Considered in terms of cost savings over time, and its capacity to be readjusted in response to changing weather conditions or the addition of new telecommunications equipment, this environmental system was described in the language of performance, contrasting conventional tropes of banking like stability and tradition to assert the building’s role in securing commercial viability for HSBC [Fig. 4.61].

The ORBIT study concluded that the introduction of information technology into the workplace meant that “the building becomes a support structure for the work operation” rather than a speculative shell. It would then follow that office buildings would no longer be rated by “traditional locational criteria,” but instead by their capacity to adapt to the requirements of the new technology. The best-performing buildings would include: finely zoned air conditioning systems with the capacity for expansion, an over 2% ratio of vertical ducting to floor area, generous and flexible horizontal “trunking” housed in raised floors, densely spaced electric outlets, and a floor plate around 15 to 17 meters deep to maximize cellularization or flexible spatial arrangements such as “Gruppenräume.”

The study parsed the major components of a speculative office building into elements with longer life spans, such as building shell and services (50 and 20 years respectively), and more interchangeable “scenery,” and “sets,” with 5-10 year life spans. “Scenery” encompassed the major components of interior design including partitions, floor and wall coverings, ceilings, lighting, local services

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541 Ibid., 5-7.
542 Ibid., 7.
543 Ibid., 7-8, 36.
distribution, and furniture; “sets” involved the configuration of scenery elements [Fig. 4.62].\textsuperscript{544} The ORBIT study predicted greater attention to the configuration of the interior environment with the upsurge in telecommunications, especially given the impact of heat gains from densely spaced computer equipment, the cumulative effects of which could easily match solar heat gain [Fig. 4.63].

In addition to listing the usual optical concerns regarding lighting and reflections on VDU screens, the study emphasized the importance of individuals’ control over their environment through adaptations to “scenery” components like operable windows, task lighting, localized air conditioning controls, personalized workstations, and the right to external views.\textsuperscript{545} Citing a resistance to the “monotony of perfection” in office environments, the ORBIT study urged architects and developers to recognize the degree to which office design operated as “the image and medium of organizational values.”\textsuperscript{546} Because organizations themselves were projected to be more volatile in their arrangements, buildings would have to be able to accommodate change quickly through easily reconfigurable spatial structures. In addition, more stringent environmental requirements meant that services would play a more crucial role in building design and maintenance. The report recommended the incorporation of “intelligent” building facilities management strategies, combining data processing with space management to conserve energy and resources. Ultimately, the ORBIT study argued, these systems had

\textsuperscript{544} Ibid., 13.
\textsuperscript{545} Ibid., 36-37. The ORBIT study reported that the right to external views from the workplace was a legal stipulation included in building regulations in several European countries.
\textsuperscript{546} Ibid., 37.
to easily accommodate transforming business operations in an environment with “internal character, interest and quality.”

In line with the proposals of the ORBIT study, Foster Associates proposed that environmental constancy, which had become a central design objective at HSBC—intended to maximize worker productivity and to minimize energy expenditure in the face of a telecommunications revolution—could be secured through the installation of a computerized building management system (BMS). In July 1982 the bank’s board approved the architects’ proposal of Johnson Controls for the $HK 44 million BMS subcontract.

On the heels of the energy crisis that began in the 1970s, and in response to global economic recession, energy management systems incorporating fiber optic networks of microprocessors and central computers gained traction as vital components of large buildings by automatically regulating heating, ventilation, and air conditioning systems in response to signals from internal sensors [Fig. 4.64–4.65]. Many of these systems had been developed for the American aerospace industry, such as the Techloop Data Highway supplied by United Technologies Communications Company’s (UTC), a closed loop system of control for energy management systems that had originally been

547 Ibid., 102.
developed for Pratt and Whitney jet engines. The main competitor of Johnson Controls and Honeywell, UTC was one of the 50 largest industrial companies in the world in 1983. It was a subsidiary of United Technologies Building Systems (UTBS), which had consulted for NASA on building and spaceship energy control systems, using microprocessors for greater efficiency. In addition to UTC, UTBS owned a number of companies which helped to constitute its expertise in environmental regulation, including: Hamilton Standard, a company developing aircraft controls, components and equipment; Essex, a manufacturer of power and communications cables; Otis elevators; Carrier air conditioning; Mostek, a company producing integrated circuits and computer component systems; and the telecommunications company Lexar.550

Based on a fiber optic network, UTC’s Techloop Data Highway was marketed as a more efficient means of environmental regulation than the earlier systems utilizing pneumatically controlled sensors and valves, whose signals had to be converted to digital ones to be transmitted to a central computer, and then back again, with continual external adjustments required to regulate the system. The Techloop Data Highway offered a more seamless means of communication, allowing microprocessors to receive and transmit information directly to and from infra-red temperature and humidity sensors distributed throughout a building; the central processing unit, described as the building’s “brain,” then issued instructions to automatically calibrate heating, ventilation, and air conditioning systems in response to signals received from internal sensors. Eventually,

550 Peter Carolin, “Building Services; Integration and Intelligence,” *Architects’ Journal* (Nov. 23, 1983), 115-120. UTC’s closed loop direct control system was installed in a group of 33 buildings on MIT’s campus in 1977, reportedly resulting in a major reduction in payback period from 3 years to 14 months. UTC also installed building management systems at EPCOT, MIT, CityPlace, Cigna (by TAC), and La Defense in Paris, their only European project.
manufacturers planned to incorporate external sensors to record weather and sunlight data, which would be combined with meteorological reports to further fine-tune environmental and energy systems [Fig. 4.66]. This shift in energy management reflected the movement towards a more service-oriented construction industry, where engineers and facilities managers provided preventative maintenance, using digital technology to fine-tune increasingly complex building systems [Fig. 4.67].

Banks were the most enthusiastic early adopters of intelligent building systems technologies, which were integrated and installed during the construction of buildings in order to implement the most seamless environmental calibrations. In addition to HSBC, some of the earliest institutions to occupy or plan buildings with intelligent-systems technology included Dean Witter Reynolds and Merrill Lynch in Hartford, Connecticut; Barclays, National Westminster, Paine Webber, and Equitable Life in New York City; Société Générale in Dallas; and Citicorp in San Francisco. A September 1984 article in Euromoney magazine posed the question: “Intelligent Buildings: Smarter than their Bankers?” It argued that the most critical area of expenditure for the majority of businesses was not the cost of labor but the upsurge in energy costs; in order to maximize profits, companies had to employ efficient energy management systems [Fig. 4.68]. A tipping point had been reached following which property owners would redistribute

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551 Richard Evans, “Are Bank Buildings Smarter than the People Inside Them?,” 62. The Techloop Data Highway also communicated with the structural, cladding, lighting, elevator, safety, and access systems.

552 Carolin, “Building Services,” 120-130. Echoing Foster’s call for tuneability, the president of Building Systems Company, the branch of UTC responsible for producing building management systems, claimed that the Techloop Data Highway and other building management systems represented a general move away “from a period of constructing buildings to a period of fine-tuning them,” 130.

escalating energy costs in the form of increased charges to tenants, who would consequently seek the most energy efficient buildings to occupy.\textsuperscript{554} In the face of a telecommunications revolution, intelligent building management systems maximized profits, and banks were enthusiastic early adopters.

As a paragon of integrated telecommunications, the \textit{Euromoney} article named CityPlace, completed in 1980 in Hartford, Connecticut. The building was outfitted by United Technologies Communications (UTC), occupied by Merrill Lynch and Dean Witter Reynolds, and designed by Skidmore, Owings, & Merrill [Fig. 4.69]. But although UTC described the project as “‘an architectural as well as a technological landmark that changes the way people do business,’” the company had rejected any external expression of the high tech systems the building comprised.\textsuperscript{555} Instead, the article explained: “UTC were anxious that its intelligence shouldn’t shine too brightly. The red-pink granite on the building’s facade was quarried 6,000 miles away in Spain and polished in Italy to give CityPlace the same weathered hue as some of its nineteenth century neighbours.”\textsuperscript{556} While a granite veneer might have been considered an appropriate mask in Connecticut for UTC’s Techloop Data Highway, the projects selected to represent the utmost in integration of environmental and information technologies for the British ORBIT study displayed a very distinct approach towards the expression of advanced technology in

\textsuperscript{554} Ibid., 67-69. The article quoted real estate developer Richard Beitler, who claimed that on average integrated systems only increased capital construction costs by around 2%, a worthwhile investment in the future, and he criticized the building climate in the UK and Europe as lagging far behind in the incorporation of intelligent systems: “European businessmen [are] willing to accept lower quality. US businessmen like to be at the razor’s edge of technology.” The article also named Exchange Square (1983-1988), home of the Hong Kong stock exchange as well as several international banks, as the first Hong Kong building to incorporate intelligent systems management.

\textsuperscript{555} Ibid., 64.

\textsuperscript{556} Ibid.
building. Examples including Foster Associates’ IBM Pilot Head Office in Cosham, England, and Richard Rogers’ Lloyd’s of London insurance market building treated intelligent building systems and environmental efficiency as correlative with the overall enclosure or external representation of the building [Fig. 4.70-4.71]. Foster’s IBM Cosham project and Rogers’s Lloyd’s building employed smooth, reflective surfaces of glass and stainless steel, configurations that emphasized techniques of assembly, and discrete, distinctly legible structural, service, and cladding components to express a conception of building in terms of optimized and integrated systems rather than as a single sheathed entity. The ORBIT study complemented the environmental constancy and flexibility it espoused with images of what had come to be known as “high-tech” architecture. In the case of HSBC, as well as in IBM Cosham and Lloyd’s of London, the representation of “intelligent environment” was enmeshed with the outward face of the building, which presented a symbolic image of productivity, efficiency, and profitability to be projected worldwide. High-tech in this context described both the adaptation of new telecommunications systems to architectural requirements, and the development of a compatible external language that could promulgate the new model of environmental efficiency for commercial prosperity.

Value and Image at the Bank

Due to their simultaneous construction schedules, their entanglements with the financial and insurance industries, and perceived similarities in their formal languages, Foster’s HSBC and Rogers’s Lloyd’s of London buildings were frequently correlated in

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architecture journals of the period, which described the technical feats of both buildings to illustrate how each constructed a global image for its respective institution.558

While their architects presented the peripheral plug-ins—i.e. external stainless steel staircase towers at Lloyd’s and outwardly positioned stair towers and toilet modules at HSBC—as optimizing maintenance processes, formal analyses of the projects tended to focus on their representational capacity.559 Describing HSBC and Lloyd’s as “multi-screen electronic terminals in the financial wiring of two large cities,” Martin Pawley differentiated the external forms of the two structures by asserting that while the exterior stainless steel staircase towers were the most prominent components of the Lloyd’s composition, the HSBC building read more as a single object, despite its externally positioned stair towers and toilet modules.560 According to Pawley, this difference corresponded to the distinction between an “unbundled” machine with peripherals as discrete elements, like an Atari computer, and a “bundled” machine, with all components housed in a smooth continuous casing, like an Apple Macintosh [Fig. 4.72-4.73]. If the unbundled machine was a cheaper means of accommodating productive activity, then Pawley suggested that HSBC was “either more advanced or inherently more expensive”

558 Ove Arup and Partners were the structural engineers for both HSBC and Lloyd’s, but the HSBC team was led by Jack Zunz, Arup’s joint chairman who had worked previously on Sydney Opera House, Swindon’s Renault warehouse, and Stirling’s Staatsgalerie in Stuttgart. The Lloyd’s team was led by Peter Rice, who had worked on the Centre Pompidou, as well as Rogers's PA Technology Centre in Princeton, NJ, and Renzo Piano’s Menil Gallery in Houston. See Peter Carolin, “Two Engineered Solutions,” Architects’ Journal 184, 43 (Oct. 1986), 79.
559 Some critics argued that the external structure and service elements had little to do with peroformance, and merely optimized occupiable floor space to maximize profits. See Alan Cheung and Patrick Hannay. “A Tale of Two Architectures: Appraisal: Lloyds, Hongkong and Shanghai Bank,” Architects’ Journal 184, 44 (Oct. 1986), 31.
than strictly necessary.\textsuperscript{561} His computer analogy was an attempt to reconcile a slippage between the image of precision and actual performance. If these buildings were the product of “a fusion of information technology with financial management that is creating a new kind of building and providing the massive economic resources to develop it,” as Pawley claimed, then their external expression suggested a mechanical mastery over less palpable techniques of trade and finance.\textsuperscript{562}

While functionalism historically assumed both literal and representational resonances, Pawley did little to acknowledge this binary significance of the term. Architects like Foster and Rogers were commissioned for their capacity to demonstrate mastery of both the hardware and the software, the physical and immaterial aspects of information and financial exchange. Exact fit and adaptability to changing conditions mattered more in this context than stability or permanence, and maximum precision in assembly and environmental regulation supported that approach, by both representing and creating the spatial conditions to sustain an increasingly risk-based, digitized financial market.

Pawley’s mentor Reyner Banham asserted that there was an ‘au courant’ aesthetic important for marketing financial institutions: “It is important for these institutions to

\textsuperscript{561} Ibid., 114-115.
\textsuperscript{562} Ibid., 113. Key to Pawley’s analysis, though not made explicit in his text, was an investigation of the formal relationship between part and whole. Peter Buchanan made a more conventionally art historical analysis when he categorized Foster’s work as classical, with closed, complete forms: “‘The promise the buildings pursue, is perhaps that of pure performance, or a liberation through technics to an unencumbered egalitarianism, but within a tightly defined (and so limiting) and orchestrated whole.” By contrast, Buchanan deemed Rogers’s work more gothic for its individualism, variety, and open-ended form. For Buchanan, the distinction between holism versus fragmentation was merely a means to situate the high-tech buildings of Foster and Rogers within the long history of architecture. See Peter Buchanan. “Foster - Rogers: High-Tech: Classical, Gothic,” \textit{Architectural Review} 196, 1011 (May 1981), 265-267.
look smart, efficient, and up to date. A building like Lloyd’s or Hongkong persuades the public that however conservative money may be, the people who manipulate it are really with it and up to the moment.”


The merit of this lavish exterior detail, Drexler argued, was to naturalize current technologies, a worthy form of expression even for a profit-driven skyscraper: “No architect can be indifferent to these seemingly superficial problems. The kind of image a building leaves in the mind is a substantive architectural question despite its being raised by commercial developers rather than, say, the church.”

In considering the “externalization of detail” in purely formal terms, Drexler overlooked the degree to which this operated in the service of, rather than despite, the “High Tech” building as profit machine.

While historians and critics like Drexler, Pawley, and Banham evaluated the formal expression of the HSBC headquarters as a symbol of global finance, they failed to recognize the building’s technical means of constructing an environment for economic activity. This celebration of the external manifestation of technology distracted from the use of architecture’s material techniques to produce security through environmental

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564 Arthur Drexler, *Three New Skyscrapers* (New York: Museum of Modern Art, 1983), 6. The HSBC headquarters were displayed alongside the National Commercial Bank in Jeddah, Saudi Arabia, by Skidmore, Owings and Merrill, and the International Place at Fort Hill Square complex in Boston by Johnson/Burgee architects. Drexler also claimed that HSBC provided 75 percent usable floor space, compared to 60-65 percent on a conventional 40-story office tower, providing the bank a 65-million-US dollar bonus.
565 Ibid., 3, 6.
control [Fig. 4.74]. The messiness of markets, currency fluctuations, and energy shortages were counteracted by the clean, smooth regulatory mechanisms of HSBC’s envelope and environmental management systems. Transparency made that control visible to the outside world, imparting “a surreal and strongly alienating sense created by those sealed glass bubbles full of blue suited insurance brokers...”\(^{566}\) This was certainly an elevation of technical processes over social programs, as Alan Colquhoun argued of that archetype of High Tech architecture—the Centre Pompidou by Richard Rogers and Renzo Piano.\(^{567}\) But far from relinquishing control over architecture’s representational aspects, at HSBC and at Lloyds Foster and Rogers manipulated the image and performance of technological systems for commercial gains.

What exactly constituted advanced technology at HSBC? The headquarters’ exterior form and envelope were both of technique and about technique, of image and about image.\(^{568}\) In this instance of containment, excessive precision was inextricably linked to the generation of capital, symbolizing the dexterity of the institution in both local and global contexts. Equally, though, technical precision was a principle for the

\(^{567}\) In his critique of at the Centre Pompidou in Paris, which Richard Rogers completed with Renzo Piano in 1977, Alan Colquhoun questioned the building’s coupling of *culture* with *information*, in that it was treated as a “flexible service mechanism” able to be filled and programmed by any occupant. The problem for Colquhoun was that the architects had ceded control over the representative and social roles of building, leaving architecture “no further task than to perfect its own technology.” By accentuating transparency, flexibility, and function, the architects were celebrating a notion of process without articulating its ends. Alan Colquhoun, “Plateau Beaubourg,” in *Essays in Architectural Criticism: Modern Architecture and Historical Change* (Cambridge, MA: MIT Press, 1981), 114  
regulation of interior space, itself a marketable feature. At HSBC, the building management system, glazed curtain wall, and other constituent techniques of the internal environment were mobilized to accrue value by predicting optimal future performance. The new headquarters stood as a figure of the contemporary world order, as environmental control was codified for commercial gain, the center of financial power shifted from West to East, and private capital had begun to supplant the state [Fig. 4.75-4.76].

At the time, the political and economic future of Hong Kong hung in the balance. HSBC’s acquisition of the New York-based Marine Midland Bank in 1979 had signaled its transition to a more geographically dispersed multinational institution, and following the opening of the Chinese economy under Deng Xiaoping the Bank established offices in Beijing and in China’s Special Economic Zones. Despite its presence in China and in the West, however, over 50% of the Bank’s profits came from its Hong Kong operations. The new headquarters building was to cement HSBC’s foothold in Hong Kong, where it issued 80% of the banknote currency and functioned as principal bankers to the Government, its director ranking second in the colony’s power structure to the Queen-appointed governor.\footnote{King, 861.} \footnote{Patrick Hannay, “Two Politics of Patronage,” Architects’ Journal [“Lloyd's and the Bank: Special Issue”] 184, 43 (Oct. 1986), 70-74.} The institution therefore assumed a unique position in between an outwardly expanding business and an inwardly focused center of colonial power, enmeshed within Hong Kong’s governmental framework.

When Margaret Thatcher met with Deng Xiaoping in 1982 to discuss the termination of Great Britain’s lease over the New Territories in 1997, she dismissed
Deng’s “one country, two systems” proposal, in which Hong Kong would remain a capitalist enclave under communist Chinese control for 50 years following the handover [Fig. 4.77]. This led to a precipitous drop in confidence in the Hong Kong dollar. Hong Kong’s Hang Seng index fell 50 percent below its 1981 peak in the months following the talks and HSBC shares declined sharply, not recovering until 1986, well after the Hong Kong dollar was pegged to the US dollar and the new headquarters were completed [Fig. 4.78].

The cost controversy over the building emanated from this economic slump. Initially seen as an emblem of Hong Kong’s political and economic stature, it began to be perceived as an extravagance by a major private sector bank. Due to HSBC’s quasi-governmental status, value in the new building was a relative concept, conforming to each new metric of future revenues. While the headquarters epitomized the institution’s dominance, even figuring on newly issued banknotes, subsumed within its glazed exterior walls were the strains of coincident perceptual, environmental, and financial concerns, the negotiation of which involved modes of inquiry and communication that signaled architecture’s changing relationship to global corporate culture [Fig. 4.79]. Properties such as flexibility, transparency, and adaptability—once associated with modernist

571 The new headquarters building was also given a 50-year lifespan.
democratic ideals—were co-opted to symbolize the business of banking. Exploited by the bank to offset the costs undertaken in the production of a new space for financial operations, mutability had assumed value in and of itself.\textsuperscript{573} HSBC had to demonstrate fluency as Hong Kong converted to a sovereign territory of China, and its headquarters functioned as a tightly conditioned machine to transform the ever-changing financial risks of the present into future profits.

\textsuperscript{573} In interviews following the bank’s completion chairman Michael Sandberg proclaimed its savings in maintenance and energy costs, explaining that “[t]he building had to be able to respond to an unknown future,” and Norman Foster echoed: “The only constant is change.” See Hexagon Productions with Hawke Films Production. \textit{One Queen’s Road, Hong Kong}. [VHS tape]. Hong Kong: Hawke Films Production, 1986.
**Conclusion:**
*Enclosure in an Environment of Uncertainty*

This dissertation has examined the ambiguities of precision in the design and construction of architectural enclosures over a forty-year time span, from the mid-1940s to the mid-1980s. During this period, the notion of precision underwent a number of vicissitudes in relation to the material, economic, and environmental factors that impinged upon its definition within building. In my analysis I have attempted to demonstrate the cultural resonances of the curtain wall, a technological object that functions to define enclosure, to modulate interior environments, and as an externally legible surface.

This dissertation has also charted the ways in which the category of environment was formulated and represented through material and analytical techniques of architecture and engineering, as well as through a developing discourse on environmental management. I have drawn parallels between localized techniques of environmental containment and regulation, and worldwide problems of resource scarcity, energy shortages, and the accommodation of laboring, productive bodies within large-scale technological systems. I have argued that interior environments, precisely defined by techniques of enclosure and management, constituted inwardly focused spaces quite separate from the outside world, even as they formed tightly contained microcosms. In a period marked by the “universalization of particularism, and the particularization of universalism,”\(^ {574}\) local environmental precision emerged as an attempt to counteract widespread social and environmental perplexity. Hermetically sealed and air-conditioned

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sunlit gardens presented a techno-aesthetic complement to increasingly imperceptible but pervasive technologies of production and exchange, a means of habituating workers to a new global order.

Together, the case studies of this dissertation describe the ways in which techniques for materializing curtain walls were conditioned by changing relations between corporations, government, and society. The United Nations Secretariat building’s smooth glass skins and controlled interior environment were designed to epitomize a formulation of internationalism that was dependent upon technical innovations like materials science and air-conditioning to best accommodate the bureaucratic and economically-driven programs of the institution. The Cummins Subassembly Plant at Walesboro used material techniques of enclosure and environmental regulation to develop a corporate industrial space that could simultaneously enhance employee diversity, productivity, and commercial gains. This model of interiority was a microcosm of spatial and environmental structures to be projected globally. The development of the glass envelope for the Willis, Faber & Dumas Headquarters building involved a highly empirical research and design process to minimize its components, effectively dematerializing the building to emphasize the conditioned bubble of air it contained. This open, empty interior workspace was designed to increase productivity through flexible spatial configurations, but also through an inwardly focused severance from the social space of the urban sphere. Finally, the realization of the glazed exterior envelope of the HSBC headquarters required negotiations over its perceptual, environmental, and economic implications. The transparent skin was seen to complement banking activity, as a component of a flexible
environmental system capable of adapting to changing technological, financial, and political conditions. These case studies each involve the intersection of several key themes, including: technical research and performance; precision and value; scale, and environment as microcosm; the corporation and society; and enclosure, interiority, and externalities.

I have contended that conventional and canonical histories of architecture’s techniques failed to consider the ways in which these visible and invisible components of building operated beyond mere functional expedients, and I have argued that they should be examined as constituents within a much broader technological system that ranges from the development of industrial materials to techniques of global financialization. In that sense, the curtain wall’s status was gradually transformed over the period studied here, from a catalyst for technological invention to an instrument that can be read as a support for much more convoluted technical processes.

The case studies presented in this dissertation trace the nuances of this transformation. In leading the reader through these fine-grained technical explications of building fragments and the exchanges between figures involved in the design and production of these curtain walls, I wanted to illustrate the way in which precision was continuously defined as a critical aspect of enclosure’s formation. It was therefore necessary for me to closely scrutinize archival documentation in order to build a comprehensive picture of the intricate links between material studies, drawings, models, calculations, measurements, testing procedures, and an expansive discourse on perceptual and spatial experience.
Through my analysis of technicity within the composition of the curtain wall I have sought to treat these building fragments as techno-aesthetic objects; I want to scrutinize the intersection of technical performance with aesthetic motivations. Precision and exactitude were consistent tropes of the curtain wall’s techno-aesthetic justification, and the various standards of measurement and methods of technical assessment often operated as contrivances to bolster this rationalization and appraisal of precise enclosures.

In relation to the frequently disordered social, environmental, and economic contexts of these case studies, the architectural precision examined here represented a stabilizing force. Localized control eased the adjustments requisite for attaining exactitude within a flexible assembly of components. In that sense precision in these projects was reliant upon the notion of *intertuneability*, or the modulation of relations within a ‘synthesis of systems.’ The various forms of representation bear this out, as sketches, calculations, technical drawings, models, and mockups were deployed together as devices to ensure the precise configuration of components. But precision also served to counterpoise the more nebulous conditions surrounding this work, such as the divergent aesthetic, material, and economic agendas of various collaborators; competing standards of environmental efficiency; and the fraught commercial and political interests of clients. Certainly, the common objective of precision promised an efficient use of materials and energy, but it also suggested a shared interest in architecture’s capacity to manage spatial and technical relations.

The problem of scale was central to this project, as I endeavored to show the ways in which buildings’ minute technical components were integral to larger technological and social processes. Within each case study I have charted the reverberations between
discrete technical objects and the social conditions surrounding their formation. Likewise, I have shown the interrelatedness of precisely defined interior enclosures and the diffuse economic machinations they were made to serve. It is not simply that I want to show how these small-scale constructions reflect broader processes, but rather that I want to demonstrate how expansive technical systems and processes must be understood as comprising even the most miniscule entities. In establishing how small parts become integrated within large and complex wholes, I have also sought to exemplify the way in which interior environments came to operate as microcosms of much broader external environments. To that end, enclosure is treated here as an entity that is technically defined but has extensive social ambitions and consequences. At the same time this understanding of enclosure has wide-reaching aesthetic significance, both for its constitution of the external face of a building and for its part in the circumscription of an interior environment meant to regulate the psyches of office workers or factory laborers.

This study of enclosure highlights a paradox between the production of highly calibrated interiors and the globalized production of such spaces; their constitution depended upon a global supply chain of labor and material production. In addition, these tightly enclosed interiors served corporate interests dependent upon the global circulation of capital. Concurrent with the exponential distribution of information and goods under a globally oriented system of financialization, interior enclosures were formulated as spaces of withdrawal from an array of externalities in the period, including social and ecological deterioration. As these techniques of containment began to compose the spaces of neoliberal capitalism, the internality of the architectural enclosures examined here correlated to social and political externalities—as in a factory meant to correct social
division through environmental sensitivity, or an office space meant to supersede urban networks of communication and social engagement.

Technically, these types of enclosures differed in that the factory spaces I examine were designed as loose-fit containers to accommodate operators of industrial machinery and their managers within a generally pleasant and stimulating ambiance, whereas the offices I study—from the UN Secretariat building to the HSBC headquarters—were intended to be more individualized environments, calibrated to create optimal visual conditions and ideal standards of comfort for workers, with an emphasis on the physical requirements of the individual body as much as on psychological needs. In all cases, however, this analysis of enclosure may be viewed as intimately linked with the formulation of capitalism, and can be related to conceptual frameworks that cast capitalism’s enclosure of the commons in terms of privatization, or the ‘spatial mechanisms of dispossession.’

Who were the subjects of this model of interiority? They were the individuals who collaborated within this web of interlinked industrial, financial, and governmental interests. They were the laborers employed to effectuate commercial expansion. They were the figures of the architect’s social and environmental imaginary, those occupied bodies whose work was made more palatable by the provision of regulated sunlight, a temperate atmosphere, and views to their surrounds, even as they were compelled to remain within the confines of the carefully controlled work environment. Peering out

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from their glass bubbles in Walesboro and Ipswich, these workers were far removed from social unrest in Detroit, Newark, Brixton, or Bradford.

This history of enclosure frames environment as a series of contained relations, conditioned by a shift from the end of imperialism and the decline of the nation state to the integration of the state within processes of financialization. Within this framework, the technical object of the curtain wall evinces an articulation of precision devised to obscure manifold processes of encroachment upon the communal sphere. When the highly calibrated interior environment operates as a means of dissembling social and economic inequity beyond a building’s limits, it becomes crucial to read the specificities of the boundary condition in relation to all that is uncontained, unbalanced, and uncertain.
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