

Acoustic Panel Ceilings: Origins

KEITH PEIFFER

Oklahoma State University

Keywords: acoustical panel ceilings, industrialization, standardization, universal space, anonymous history.

Acoustical panel ceilings (APCs) are a mainstay in contemporary architecture. As a flexible, modular system of cross-T frames and solid panels suspended from the structure above, the APC provides the enclosure above many of the spaces we inhabit everyday: schools, offices, hospitals, and retail stores. It is a humble system, functional yet inexpensive, and it is everywhere. If “the secret ambition of design is to become invisible” as Bruce Mau asserts, then the APC has achieved this hallowed place within design as an assembly that performs effortlessly while often receding into the background, ubiquitous and taken for granted.

Its current status as a background material, however, belies its revolutionary beginnings. Although certainly not limited to this lineage, the contemporary APC was birthed as an innovative materialization of the aspirations, conflicts, and contradictions within Modernism, and is particularly indebted to the slab-style office buildings of the 1950s. To establish this context this paper will explore Modernism’s interests in standardization and industrialization of building components, clear-span universal space, and the integration of new technology through the following precedents: Mies van der Rohe’s clear-span pavilions, architectural magazines, product advertisements featuring renderings by Helmut Jacoby, and three 1950s high-rise office buildings. The confluence of these interests, explored in architectural practice, spurred more than a decade of focused development of the suspended ceiling in the 1950s, resulting in the Acoustical Fire Guard product that closely resembles the APC still installed broadly today.

Although architectural history and theory has not often mentioned the APC specifically, we can trace broader disciplinary influences to their manifestation in the APC. My interest is not in arguing for a newer or better alternative ceiling system, but in placing the APC at the center of the story, synthesizing various theoretical, historical, and technical developments to return to its beginnings with fresh eyes.

INTRODUCTION

Acoustical panel ceilings (APCs)¹ are a mainstay in contemporary architecture. As a flexible, modular system of cross-T frames and solid panels suspended from the structure above, the APC provides the enclosure above many of the spaces we inhabit everyday: schools, offices, hospitals, and retail

stores. It is a humble system, functional yet inexpensive, and it is everywhere. If “the secret ambition of design is to become invisible”² as Bruce Mau asserts, then the APC has achieved this hallowed status as an assembly that performs effortlessly while often receding into the background, ubiquitous and taken for granted.

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CONTEXT

Although architectural history and theory has not often mentioned the APC specifically, we can trace broader disciplinary influences to their manifestation in the APC. In the introduction to *The Architecture of the Well-Tempered Environment*, Reyner Banham made a passing reference to the suspended ceiling as a truly revolutionary invention, overlooked because of a disciplinary preoccupation with exterior forms.³ Banham may be somewhat biased in his analysis, as his provocative assessment is tied to his investigation into the interaction between architecture and mechanical services, but to this day the APC has received little critical attention from an architectural history and theory perspective. Although Banham dedicated almost an entire chapter to the more general concept of the suspended ceiling, his focus centered on its role as an armature for tempering interior space and not the particular instance of the APC.

Sigfried Giedion’s *Mechanization Takes Command* was published before the development of APC, but it provides an important disciplinary foundation through the telling of an anonymous history, a narrative focused on seeing humble things with “unworn eyes.”⁴ The significance of Giedion’s work was noted by Banham, who saw it as a tentative beginning to his own exploration of the impact of mechanical systems on the design of buildings. More recently Stephan Truby, in the introduction

to Rem Koolhaas's *Elements of Architecture* publication, also returned to Giedion's "focus on things easily underestimated in the everyday"⁵ as the motive for the entire exhibition at the 2014 Venice Biennale and the subsequent book project. Despite featuring a suspended acoustic panel ceiling in the installation in the Central Pavilion, however, the *Elements* exhibition scope was so vast and ambitious in covering the entire history of the ceiling (as only one of 14 total "elements") that it could not possibly cover its subject matter comprehensively. The APC received limited coverage in the *Elements of Architecture* exhibition and publication since this vast research effort focused on the suspended ceiling, dubbed the "sandwich ceiling,"⁶ and nevertheless tended to favor the novel and obscure over the quotidian.

Reinhold Martin, in his exploration of corporate architecture in *The Organizational Complex*, connects back to *Mechanization Takes Command* as well. Martin's analysis of mid-century corporate architecture focuses heavily on the curtain wall as both an image of and outcome of this organizational logic, but his work establishes a conceptual framework that influenced the ceiling plane and the APC as well.

Since the APC is the most commonly used form of the suspended ceiling lauded by Banham, its story continues Giedion's work, builds on Banham's observations, thickens *Elements'* exploration of the ceiling, and extends Martin's analysis. As Koolhaas's attempt to view architecture through its *Elements* aimed to legitimize the more mundane aspects of architecture through a disciplinary lens, this story will reconnect the APC to more widely known disciplinary moorings. The goal is not to argue for a newer or better alternative ceiling system, but rather to reflect on the history of this material as a significant example of Giedion's claim that "objects are outgrowths of fundamental attitudes to the world."⁷

While alternative suspended ceiling systems also developed during this time, this paper will focus on the most common form of APC still being installed today. The standard APC system is composed of 2'x2' or 2'x4' modular acoustical panels, typically made of either mineral fiber or fiberglass with a fissured surface, and supported by a metal suspension system hung from the floor or roof structure above.

STANDARDIZATION

Modernism's preoccupation with industrialization is well established within architectural history. The particular prominence of this interest within the disciplinary discourse of the mid-1950s is evident in the June and November issues of *Progressive Architecture (PA)* in 1957; as a pair, they highlight the convergence of standardization with the typology of the high-rise office building.

The June issue is a special feature on the high-rise office building, emphatically declaring it "the best-known symbol

of U.S. architecture today"⁸ and highlighting 12 recently completed projects. The coverage of its subjective matter reveals a logic of standardization through its emphasis on technical stats:⁹ mullion spacing, typical bay modules, floor-to-floor heights, and materials & methods (highlighting the use of curtain wall, exterior cladding, and air-conditioning systems) all represented in the exact same manner. In describing *PA's* survey, Martin notes the way that the presentation of quantitative aspects of design essentially established "the science of the office" as a formulaic approach to the typology that suppresses qualitative differences found in prestige buildings.¹⁰ Instead the editors of *PA* presented the high-rise office building as a standardized approach to addressing a particular set of constraints and objectives.

In a similar vein, the November issue focuses more broadly on the question of standardization and modularization, bringing together several articles, case studies, and product advertisements centered around the concept of modular assembly. In attempting to build a robust case for prefabrication, the magazine presented a seemingly endless barrage of quotes from prominent construction product manufacturers as well as well-known Modernist architects like Mies van der Rohe, Walter Gropius, Gordon Bunshaft, Richard Neutra, and Frank Lloyd Wright. Perhaps best encapsulating the overarching ethos was a quote by Gropius advocating an "infinite variety of interchangeable, machine-made parts for building"¹¹ that could be used to create unique buildings.

The editors of *PA* presented Modular Measure as the answer to achieving greater integration. To ensure that disparate products could fit together without on-site adjustment,¹² manufacturers had to agree to a common system to guide dimensions for their products. Building on Albert Bemis's initial proposals for a "cubical modular method" from the 1920s-30s, the American Standards Association¹³ developed Modular Measure in 1945 as a dimensioning system based on a 4" grid. Modular Measure sought to integrate design and construction, feeding the modular quality of the building components back into design using a literal grid underlay for the construction documents. Although architects never really implemented the Modular Measure grid on a broad scale, the dimensioning system did influence the nominal dimensions of building components. As Martin noted, the grid was the dominant image for standardization and hundreds of office buildings following the war did implement aesthetic techniques of modular coordination.¹⁴

It is within this context that the suspended ceiling continued its evolution. Manufacturers realized the enormous economic potential for effective coordination, so a plethora of brands competed for market dominance during the 1950s.¹⁵ The grid supporting the ceiling became the dominant ordering device of the system. Panel sizes became standard, and "a dimensional inertia"¹⁶ developed by 1947 as the ceiling grid began to constrain the other products that were integrated within the



Figure 1. Ceiling plane at Crown Hall, IIT. Credit: collage by author of photograph by Pete Sieger.

suspended ceiling. Eventually “the tyranny of the tile format was to become almost absolute, so that even long-established products had to conform.”¹⁷ The continued standardization of ceiling panel sizes is demonstrated through a survey of current acoustical materials in *PA* in late 1952. The article summarized the varieties of acoustical ceiling products on the market, with panels standardized in 12” increments (12”, 24”, 48”) while the materials (cellulose-fiber, mineral wool, fiberglass, asbestos, metal, and cork) and installation methods (direct attach, furring strips, and suspension systems) still varied considerably.¹⁸

UNIVERSAL SPACE

The APC also found its beginnings in Modernism’s interest in flexibility as an expression of functionalism. In particular, Mies van der Rohe explored these goals through the creation of “a universal, entirely open, and entirely flexible space.”¹⁹ Mies refined this typology through the use of clear-span steel structural systems that eliminated the need for interior columns. He explored the ideals of clear-span universal space in conceptual projects like *Museum for a Small City* (1941-43) and *Concert Hall* (1942) before finally realizing them on a residential scale in the *Farnsworth House* in 1952. From there, Mies increased in scale to create his “single great room,”²⁰ measuring 220’ long by 120’ wide in *Crown Hall* at IIT (1956).

Mies used techniques of reduction and concealment to reinforce the clarity of the space in these built projects, and the ceiling played a significant role. At the *Farnsworth House*, the ceiling was rendered as a continuous white plastered plane devoid of any joints, while the larger ceiling at *Crown Hall* was composed of modular 12”x12” acoustical tiles. The ceiling was reduced to a continuous surface in which provisions for sound, light, and air are consolidated by being recessed into the plenum space above. However, critics found this early

integration somewhat unsuccessful in its aesthetic reduction. Although a review in *Architectural Record* generally effuses praise for the building, the critic identifies the ceiling as one notable shortcoming in the way that lighting, air diffusers, and sprinkler heads contrast with the ceiling too sharply and undercut the purity and clarity of the ceiling plane.²¹ In spite of the attempted acoustic treatment of the ceiling, the openness of the space also ensured the squeaking of students’ drafting stools was also “‘universally’ audible.”²²

The suspended ceiling is a key component of “modernism’s ‘look-no-hands’ approach – the miracle of the flexible, minimal, open plan, with little evidence of how interior conditions were sustained.”²³ In these projects, Mies attempted to distill the ceiling to a flat plane, effortlessly defining the upper limits of the space while concealing the innovative clear-span structure that makes the space possible. Technical literature discussing acoustics showed an alignment with theoretical intent, in declaring that the ceiling systems conceal building services to “produce a clean, modern appearance.”²⁴ Citing now well-worn contradictions within Modernism, Banham highlights the inherent tension in the use of the suspended ceiling for an architectural style committed to an honest expression of a building’s structure and services.²⁵ In reflecting on the APC, it is significant to note that this tension finds material expression in the suspended ceiling.

For Mies, unobstructed, column-free space meant flexibility, maximum freedom for the building’s occupants to use it in any way they wished.²⁶ Of course, this was not limited to Mies’ work. In introducing their June 1956 survey of the high-rise office building, the editors of *PA* somewhat disparagingly acknowledge the common image of flexibility represented by the high-rise office building as “slices of horizontality piled



Figure 2. “Slices of horizontality piled vertically” (collage of Crown Hall). Credit: collage by author of photograph by Hagen Stier.

vertically, with distinction only in the conditioning of light, sound, and air.”²⁷ Formally one can easily imagine the office buildings of the time by Mies, SOM, and others as simply stacks of Mies’ universal space pavilions. Further reinforcing this conception, iconic nighttime photography of these projects by Ezra Stoller and others dramatically emphasized their layered horizontality and openness.

In the high-rise office building, Mies’ and Modernism’s ideals of universal space found particular resonance with the reality of dynamic market forces requiring flexibility. Already by the 1920s, a flexible, open plan was preferred because future changes were considered inevitable.²⁸ This typology continued to the 1950s, when a significant shift occurred with respect to flexibility. Martin notes that while earlier office buildings were based on the larger modules of the enclosed offices, postwar office buildings were driven by a smaller, more abstract grid “capable of accommodating office partitions, ceiling tiles, lighting fixtures, and furniture, in any number of combinations. Compared to the window-pier-window system of Rockefeller Center, this gridded module exhibited a lesser degree of flexibility, in exchange for a greater degree of integration.”²⁹ The grid from the curtain wall was projected inward so that the standardization and integration of building components actually began to define the organization of the universal space inside.

INTEGRATION OF TECHNOLOGY

As building systems increased in complexity and integration, the suspended ceiling developed as a strategy for incorporating new technology within the cavity created by the floor and ceiling. The Mellon Institute in Pittsburgh developed an experimental example of suspended ceiling systems as early as 1932, with Burgess and the Rivet Grip Company developing commercially available systems by 1936. In 1932 the PSFS building

featured the integration of lighting and air diffusers with the ceiling in the lobby space, which Banham touted as the first use of the suspended ceiling as a “multi-purpose membrane of concealed power.”³⁰ Popular interest in the PSFS building seems to have been revived around 1950 when the suspended ceiling became a much more significant aspect of high-rise office buildings of the time.³¹

Technology developed before the war became commercially viable “only with the impetus of a strong postwar economy and with refinements and improvements that came about through wartime efforts.”³² One example of this improvement in technology was “the triumph of air-conditioning in the 1950s,”³³ when expectations for air-conditioning shifted from a novel amenity to a near necessity. In fact, air-conditioning was the second-fastest growing industry in the United States after television at this time,³⁴ and its new dominance is evident as numerous articles in professional journals discussed how best to integrate it into building construction, particularly incorporating ductwork required to deliver conditioned air. The layer of a suspended ceiling was added to conceal the ductwork from view while providing a consistent surface with openings to deliver conditioned air to the space below.

In *Elements*, Jeffrey Inaba and Benedict Clouette highlight the evolution of building components (floors, ceilings, and walls) as “sandwiches,” composite assemblies of various industrialized building products, of which the ceiling is a prominent example. This layering leads to the creation of a somewhat mysterious *poché* space that incorporates building technology. As the interface to this *poché*, the ceiling as grid offers flexibility in that conceivably any panel can deliver any one of the building services from the *poché*. While taken for granted today, the ability for the suspended ceiling to “consolidate lighting,

acoustical absorption, and air diffusion³⁵ in a single surface was a significant development that made the suspended ceiling an integral part of the glass slabs of the fifties.

This novelty is evident as the ceiling design is covered in reviews of projects like Crown Hall and high-rise office buildings like the Lever House and U.N. Secretariat building.³⁶ Demand for acoustical suspended ceilings continued to grow, resulting in a five-time increase in sales from 1947 to 1956. Eventually the use of a suspended ceiling in tandem with air-conditioning systems was assumed, as advertisements from industry leader Carrier featured several sections showing standard solutions for integrating perimeter mechanical units with suspended ceiling systems and exterior curtain walls.³⁷

CONFLUENCE

Although the suspended ceiling was being explored in other building typologies like schools, it was a particularly strong fit with corporate architecture. In a time of economic growth after World War II, corporations were building signature high-rises as a deliberate extension of their corporate image. In fact, many of these corporations like Inland Steel, Union Carbide, Alcoa, US Steel, and Corning produced industrialized building materials and their buildings used their products as literal signifiers of the corporation.³⁸ Within this competitive market, Martin and others have focused on the evolution of the curtain wall in projects during this time. However, the editors of the June 1956 survey of high-rise office buildings identified another opportunity to distinguish one design from the rest – a consideration for interior space and specifically the modulation of light, sound, and air.³⁹ Of course, this modulation was being explored through the suspended ceiling, suggesting that the ceiling was also seen as a key opportunity for innovation in high-rise office buildings of the time.

CASE STUDIES

The following case studies—the U.N. Secretariat Building, Lever House, and Inland Steel—were selected, not because they were the first or perfect examples, but rather because they are important disciplinary reference points with respect to the suspended ceiling and issues of standardization, universal space, and integration of new technology. Banham particularly highlights the U.N. Building and Lever House as key precedents in the early integration of standardized elements into the ceiling. If the U.N. Building and Lever House are early examples of integration, then Inland Steel is a much more refined precedent. These three buildings were covered extensively in architectural journals of the time and are referenced in Banham's, Martin's, and Koolhaas's work as well. Certainly, other buildings could be offered as examples, but following Banham's lead, these projects "typify the kind of architecture done with that technique at that time"⁴⁰ rather than claim primacy.

In particular, the area where the suspended ceiling meets the curtain wall is critical to the issues of standardization, universal

space, and systems integration. This section is a negotiation between curtain wall, structure, ceiling heights, floor-to-floor heights, delivery of conditioned air, lighting, window treatments, and fireproofing in a complex set of relationships. Detailed study of the elevation, plan, and reflected ceiling plan of the case studies reveal the architects' failure to achieve complete integration of these components (see figure 3). As such, the "tension between the twin imperatives of flexibility and standardization"⁴¹ noted by Martin is materialized in the break between the ceiling and the curtain wall, between the flexibility of a customizable gridded ceiling plane and the standardization of the curtain wall that attempts to order the space behind it.

In the Secretariat, the structural bay (28'-0") and vertical mullion spacing (4'-0") allowed for alignment with the 1'-0" ceiling tiles. Despite the success of the dimensional integration of these various elements, however, the enclosed offices dictated by partitions located on the mullions proved to be an inadequate width.⁴² Lever House's structural bay matches the Secretariat, but the vertical mullion spacing of 4'-8" provided additional width for enclosed offices. While this spacing improves the functional width of the office, it dissociates the ceiling grid from the mullion grid, causing it to align only every fourth mullion.

Inland Steel, however, is a better example of standardization and integration, with *PA* touting the project as "perhaps as close as we have come to [100% Modular Assembly]."⁴³ The suspended ceiling grid is tightly integrated with the rest of the building. The structural grid is 25'-10", with equal vertical mullion spacings at 5'-2". The grid from the curtain wall is expressed in the ceiling as a channel strip that could receive modular partitions, unifying the grid that demonstrates "modular planning in three dimensions"⁴⁴ through the curtain wall, acoustical panels, interior partitions, light fixtures, and air diffusers alike. This ceiling system represented a key implementation of the suspended ceiling in which the ceiling grid is fully coordinated with the three-dimensional grid ordering the rest of the building. While the exterior horizontal spandrel bands are not a direct reflection of the interior space beyond, the interior columns found in the Lever House and Secretariat building are moved to the exterior through a clear-span structural system. At Inland Steel, SOM is more Miesian than Mies in creating an enormous room on each floor, "19 Office Floors Without Columns."⁴⁵ The suspended ceiling system at Inland Steel achieves standardization, universal space, and integration of technology.

The suspended ceiling was a materialization of the desire for complete integration of curtain wall, structure, and ceiling to create a flexible, universal space to facilitate the efficient activity of the corporation. While these projects did not include the standard APC, they are key examples of the evolution of the suspended ceiling as a device for addressing construction, theoretical, and technical issues.

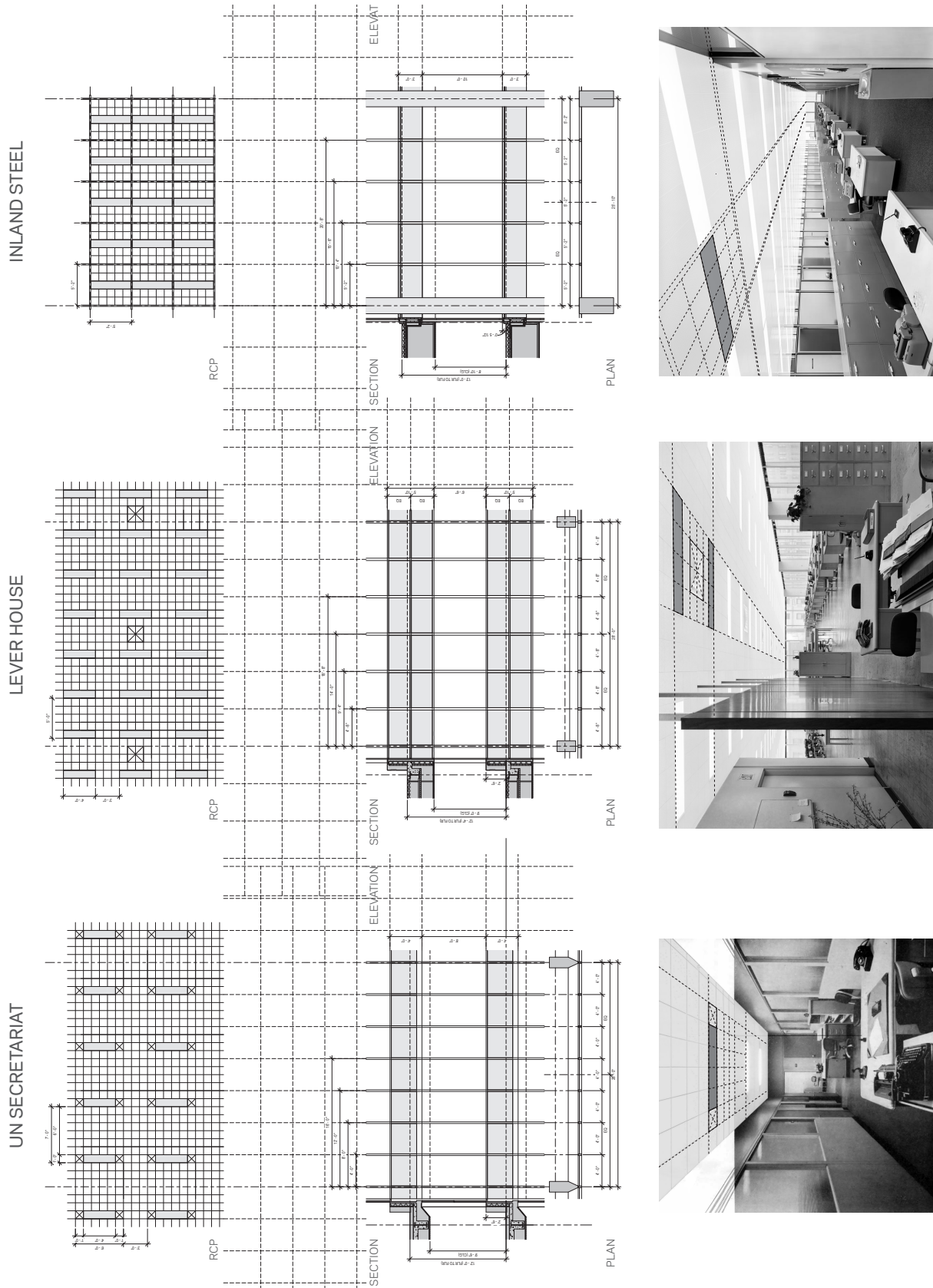


Figure 3. Comparison of integration for the referenced case studies. Credit: courtesy of the author.

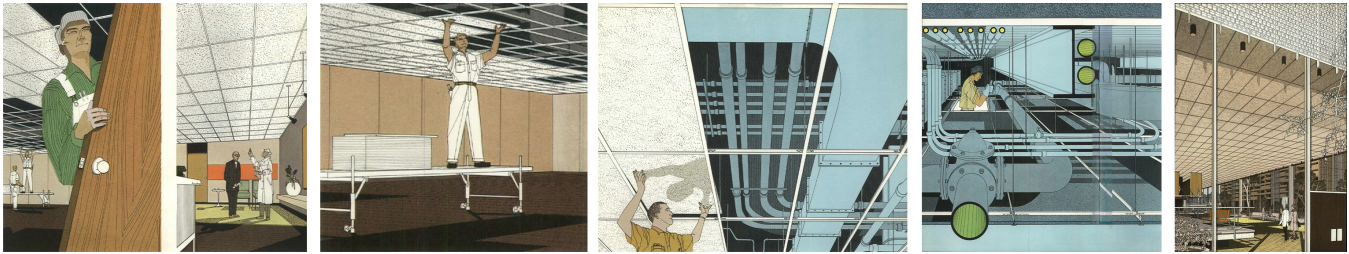


Figure 4. Renderings by Helmut Jacoby from the 1960 Acoustical Fire Guard advertisement. Credit: Armstrong World Industries.

ACOUSTICAL FIRE GUARD

In 1957, the Armstrong Cork Company introduced its Acoustical Fire Guard panel product, which their current corporate history identifies as “the most important event in commercial ceilings history,”⁴⁶ selling millions of square feet within the first couple of years.⁴⁷ This product was a development of their Minaboard product, standardized in 2x2 and 2x4 modules and set in a suspended metal grid system for easy installation and reduced cost. In 1960, Acoustical Fire Guard was included in a lay-in ceiling system that was UL-rated to protect steel for three hours, eliminating the need for additional fire-resistance treatment. Armstrong’s ads touted the system as “the first and only time-design-rated acoustical lay-in ceiling,”⁴⁸ which propelled Armstrong to “overnight recognition as the industry leader.”⁴⁹

As an acknowledgement of the significance of this product, Armstrong invested heavily in introducing the Acoustical Fire Guard system, featuring a 12-page spread in *AIA Journal*.⁵⁰ The advertisement suggests the product’s intimate connection with the ambitions of Modernism in its selection of Helmut Jacoby to provide renderings depicting the system’s assembly, applications, maintenance, and detailing. Jacoby’s role as renderer for Modernist masters like Gropius, Mies, and Johnson was well known by the time, and his inclusion appears to lend significant disciplinary weight to the importance of this product.

Through the Acoustical Fire Guard system, Armstrong achieved another level of integration of technology in which the APC added fire-resistance to the modulation of sound, light, and air. The product continued the standardization that had coalesced around the 2x2 and 2x4 modules, and it delivered a flatness that emphasized the abstraction and reduction desired of the ceiling plane. Maybe most importantly, however, the APC promised to do all of this cheaply, quickly, simply, and beautifully,⁵¹ while requiring little maintenance. It is perhaps this pragmatic utility that allowed the APC to develop into a thriving \$1.5 billion industry⁵² more than sixty years later, long after architectural discourse discarded the tenets of modernism that birthed it.

ENDNOTES

1. The term “Acoustical Panel Ceilings” was selected for use as it is the typical nomenclature for this system adopted in the MasterSpec format, section 095113.
2. Bruce Mau and Jennifer Leonard, *Massive Change* (New York: Phaidon Press, 2005), 2.
3. Reyner Banham, *The Architecture of the Well-Tempered Environment* (Chicago: University of Chicago Press, 1969), 12.
4. Sigfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* (Minneapolis: University of Minnesota Press, 2014), 3.
5. Stephan Trüby, “Elements of Architecture: An Introduction,” in *Elements of Architecture*, ed. Rem Koolhaas (Köln: Taschen, 2018), LXII.
6. Manfredo di Robilant and c-lab, “Ceiling,” in Koolhaas, *Elements of Architecture*.
7. Giedion, *Mechanization Takes Command*, 3.
8. “High-Rise Office Buildings: Introduction,” *Progressive Architecture* 38, no. 6 (June 1957): 159.
9. Reinhold Martin, *The Organizational Complex: Architecture, Media, and Corporate Space* (Cambridge, MA: MIT Press, 2003), 82.
10. Martin, 83.
11. Walter Gropius in “Modular Assembly,” *Progressive Architecture* 38, no. 11 (November 1957): 119.
12. “Modular Assembly: Introduction,” *Progressive Architecture* 38, no. 11 (November 1957): 117.
13. The American Standards Association was the precursor to the American National Standards Institute (ANSI), which continues to set standards for construction products today.
14. Martin, *Organizational Complex*, 98.
15. Martin, 103.
16. Banham, *Well-Tempered Environment*, 216.
17. Banham, 216. According to Banham, General Electric adapted their tube lengths to fit with the square 12-inch acoustic tile module, and Anemostat developed square diffusers in 1949 to fit within the square ceiling panel modules.
18. Paul J. Washburn, “Sound-Conditioning Materials,” *Progressive Architecture* 33, no. 10 (October 1952): 73–78.
19. Peter Blake, *The Master Builders: Le Corbusier, Mies Van Der Rohe, Frank Lloyd Wright* (New York: W. W. Norton, 1976), 249.
20. Phyllis Lambert, *Mies in America* (Berlin: Hatje Cantz, 2001), 197.
21. “An Architecture Building for I.I.T.,” *Architectural Record* 120, no. 2 (August 1956): 136.
22. Blake, *Master Builders*, 252.
23. Di Robilant and c-lab, “Ceiling,” 207.
24. Washburn, “Sound-Conditioning Materials,” 77.
25. Banham, *Well-Tempered Environment*, 196.
26. Blake, *Master Builders*, 246.
27. “High-Rise Office Buildings,” 159.
28. Martin, *Organizational Complex*, 87–95.
29. Martin, 95.
30. Banham, *Well-Tempered Environment*, 212.
31. Banham, 212.
32. Thomas Leslie, Saranya Panchaseelan, Shawn Barron, and Paolo Orlando, “Deep Space, Thin Walls: Environmental and Material Precursors to the Postwar Skyscraper,” *Journal of the Society of Architectural Historians* 77, no. 1 (March 2018): 79.
33. Gail Cooper, *Air-Conditioning America: Engineers and the Controlled Environment, 1900–1960* (Baltimore: Johns Hopkins University Press, 1998), 142.
34. “Air Conditioning: Booming Like Television,” *Newsweek*, September 1, 1950, 64.
35. “Mies’ Enormous Room,” *Architectural Forum* 105, no. 8 (August 1956): 109.
36. See, e.g., Suzanne Sekey, “Design and Furnishing of Offices,” *Progressive Architecture* 33, no. 1 (January 1952): 108–109; “U.N. Headquarters Progress Report,” *Progressive Architecture* 31 no. (June 1950): 65–66; “Mies’ Enormous Room”; and “Lever House Complete,” *Architectural Forum* 96, no. 6 (June 1952): 109.
37. Carrier, “Which Is the Best Way to Air Condition an All-Glass Building?,” *Progressive Architecture* 38, no. 6 (June 1957): 113.
38. Martin, *Organizational Complex*, 102.
39. “High-Rise Office Buildings,” 159.
40. Banham, *Well-Tempered Environment*, 15.
41. Martin, *Organizational Complex*, 95.
42. Martin, 95.
43. “Modular Architecture,” *Progressive Architecture* 38, no. 11 (November 1957): 158.
44. “Modular Architecture,” 158.
45. “19 Office Floors without Columns,” *Architectural Forum* 102 (May 1955): 115.
46. “A History of Armstrong,” Armstrong World Industries, 2015.
47. Armstrong Cork Company, “Armstrong Announces Another Significant Development in Fire-Retardant Ceilings,” *AIA Journal* 34, no. 6 (December 1960); 83.
48. Armstrong, 82.
49. “A History of Armstrong.”
50. Armstrong, “Another Significant Development,” 81–92.
51. Armstrong, 81–92.
52. “Investor Presentation: What’s Next,” Armstrong World Industries, April 29, 2019, accessed June 3, 2019, <https://www.armstrongworldindustries.com/en-us/investors/events-presentations.html>.