Unfolding Structure

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398 Mies van der Rohe, Farnsworth House, Plano, Illinois, 1945–51; view from the north

Farnsworth to Crown Hall: Clear Span

Robert Venturi (b 1925), one of Mies's most famous critics, recognized the transformative dynamic of Mies's work in an essay of 1978 in which he compared it to a McDonald's restaurant 399.[1] Long interested in the flows and exchanges between high and low art, Venturi turned to Mies 'to remind ourselves that Modern architecture went to the industrial vernacular for inspiration and for its forms'. For Venturi, a "factory" by Mies is vernacular art enhanced as fine art, while a McDonald's on the Strip is folk art derived from fine art'.[2] The 'Golden Arches', he noted, were appropriated from high examples of modern architecture such as the Palace of the Soviets project for Moscow (1930) by Le Corbusier 400 or, closer to home, the St Louis Arch (1947–8, 1959–64) by Eero Saarinen (1910–1961), both of which in turn were based on the new industrial vernacular of engineering works such as Eugène Freyssinnet's concrete airship hangars at Orly (1916). Venturi characterized Mies's 'almost classical orders' as an 'artful contortion' of 'the exposed steel I-beams of a certain kind of American factory' applied 'almost as pilasters, to symbolize industrial process and pure order and yet to conform to acceptable standards of fire protection for non industrial buildings'.[3]

Notwithstanding Venturi's insight, neither 'enhancement' nor 'contortion' are sufficient terms to describe Mies's work in relation to the vernacular. As we have seen before, he took up – perhaps one could say appropriated – the emerging structural types of his time such as the high-rise skyscraper and transformed them through elemental clarification into prismatic technical forms emptied of everything extraneous, purified and subtly recast as art. This process, which was intended to make manifest the immanent geometries and proportions of the building, employed a pallet of rich materials (woods, marbles and glass) and enriched surfaces (painted steel, polished stone). In similar fashion, Mies took up the long-span industrial shed and transformed it over the course of several projects into what he called a 'clear construction': the Concert Hall project of 1941–2, the Cantor Drive-In Restaurant of 1945–50, and Crown Hall of 1950–6. These constructions were not only integral or autonomous in themselves but also self-reflexive. By making manifest and legible the inner logic of his constructions – their geometric, mathematical and technical logic – Mies sought to bring technology to completion as art; or, to speak once more in the language of Karl Bötticher, to bring technical form to completion as art form. For Mies, such art forms were hallmarks of the organic. He believed that when the great form of an historical epoch finally came into visibility, it signalled the completion of an epoch and, in a Janus-like gesture, the opening of the next. This was the deeper meaning of Mies's statement that clear construction was the precondition for the variable ground plan. It was, he implied, only with the variable ground plan that new life forms could actualize themselves and usher in an architecture not yet envisioned in the present.

Mies's approach to developing, refining and expressing structural-spatial types that were generated first in the industrial vernacular – elevating *bauen* into *Baukunst* – was indebted to histories of architecture that emphasized the dependence of historical styles upon the systems of enclosure characteristic of their age. From Bötticher to Alois Riegl to Sigfried Giedion (each of whom Mies read), the architecture of earlier epochs was defined in terms of its unique, fully integrated system of construction – that is, in terms of its manner of roof covering and enclosure, which arose from the material and spiritual conditions of its time and became formalized in a particular structural-spatial type. Writing in the 1840s, Bötticher, for instance, suggested that the essence of a style was given through the system that articulated the covering of space into parts or structural units. The Hellenic style was based on a post-and-lintel system of construction, executed first in wood and then in stone, requiring massive elements, short spans and restricted floor plans, whereas the basilicas and baths of ancient Rome were based on a system of curved masonry vaults. By contrast, the Gothic style employed the pointed arch, allowing masonry structures to escape their limitations and produce wide spans, extraordinary heights and unprecedented transparency. Bötticher maintained that, just as these styles had done in their own times, any new style would have to harness the potential of the newest building material: in the late nineteenth century, that meant iron, a synthetic material not found in nature.[4]

For many proponents of modern architecture, technical forms and constructive systems were a function of evolutionary selection, development and dissemination. Le Corbusier, for instance, suggested that only through a process of evolution were the forms of objects and buildings perfected to a standard that could then be replicated through mass production, as was taking place in automobile production 401. Giedion pointed to the insertion of an iron frame by Henri Labrouste (1801–1875) into the Library of Ste-Genevieve in Paris of 1842–50 as the first instance in which columns stood freely in a space without visible beams. Le Corbusier later systematized the use of such free-standing columns in concrete, with his Domino houses of 1914–15. His Citrohan House (1922) series and purist villas of the 1920s demonstrated the Domino's potential not only for plastic expression within a free plan but also, as Giedion argued, for a new, generic architecture with which to rebuild entire cities. Mies's own efforts, in his work of the late 1920s through his early projects for IIT, sought to develop a comparable system in steel, rather than concrete; first with columns, and then with expressed frames.

Like Bötticher, Giedion mined the history of architecture to plot the trajectory of its typological development. According to him, the curtain wall attained its true form beginning with the late-nineteenth century exhibition buildings and ending with the studio wing of the Bauhaus in Dessau of 1926. He similarly tracked the development of clear-span structures, starting with the use of iron in the roof trusses of late eighteenth century theatres such as the Theatre Français of 1766 by Victor Louis (1731–1800). He showed how the iron roof became exposed and glazed with the Galerie d'Orlean at the Palais Royale of 1829–31 by Pierre-François-Léonard Fontaine (1762–1853) 415. The structure became lighter as engineers learned to exploit the tensile strength of iron, as in the entrance hall of the Gare de Nord of 1862 by Jean-Barthélémy Camille Polonceau (1813–1859), and was extended to the

399 First McDonald's, Des Plaines, Illinois, 1955

400 Le Corbusier, Palace of the Soviets Project, Moscow, 1930

401 Le Corbusier, the evolution of the car from 1900–1921; as published in *L'Esprit Nouveau*, 1921

402 Museum for a Small City; as presented in 'Museum: Mies van der Rohe, Architect, Chicago, III', *Architectural Forum*, May 1943

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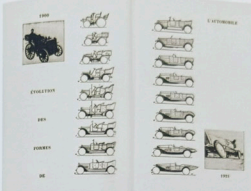

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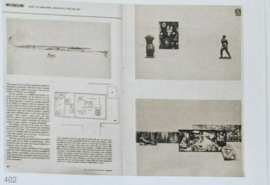

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ground with the Rue Madeleine-Market Hall of 1824 by Marie-Gabriel Veugny (1785–1856) and later in Les Halles of 1853 by Victor Baltard (1805–1874). Focusing on these Parisian examples, Giedion did not here include the Crystal Palace in London's Hyde Park of 1851 by Joseph Paxton (1803–1865), but he gave it due place in other writings.[5] The tendency towards a complete constructive system in iron and glass continued with larger and more publicly significant structures developed in the mid-to late nineteenth century, such as train stations, department stores and exhibition buildings. The Galerie des Machines in Paris of 1878 by Henri de Dion (1828–1878) was the first to carry all the forces of the system into the foundations without tie rods. This linear development culminated in the enormous Galerie des Machines of 1887–9 by Charles Louis Ferdinand Dutert (1845–1910) 416. Encompassing a space 115 metres by 420 metres (380 feet by 1,380 feet) and 45 metres (150 feet) high, Giedion called this limitless space 'an unprecedented conquest of matter'.[6]

An earlier historian, Alfred Gotthold Meyer (1920–1998), also alluded to a technological sublime when he maintained that structures like the Galerie des Machines, *Crystal Palace* and the Eiffel Tower (1889) introduced not only a new scale but also a new atmospheric spatiality and a new steely beauty.[7] Phyllis Lambert noted that an enlarged copy of the famous photograph of the Galerie des Machines was found in the Mies Collection of the University Archives of IIT, mounted on board with grommet holes, which suggests it was used for teaching.[8] She describes this as 'an indication of the powerful alliance of space and structure in [Mies's] mind'[9] and a possible inspiration for the FourDry Hall of his Minerals and Metals Building of 1941–3 and Concert Hall project. If the Minerals and Metals Building was Mies's first effort to express structure in America, it was also his first clear span building. He had been exposed to this type while working for Peter Behrens on the AEG Turbine Factory back in 1909–10 417. His article on 'industrial construction' of 1924 was illustrated with a contemporary industrial shed by Behrens of 1910 as well as a barn by Hugo Häring of 1924–5 that used modern laminated wood.[10]

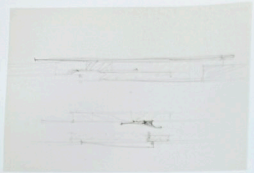
While working on the Minerals and Metals Building, Mies undertook two hypothetical projects that explored different formal and spatial paradigms for programs requiring large floor areas: the Museum for a Small City (1940–3) and the Concert Hall. The museum was an expansive, single-storey horizontal space: a column grid, as at the German Pavilion at the Brussels Exposition (1934–5), contained within a rectangular precinct that in turn contained garden courtyards as well as figural rooms. 404, 405 It was a conceptual project that grew out of George Danforth's student thesis at IIT (1940–3) and was developed for a special issue of *Architectural Forum* on 'New Buildings of 194X', published in May 1943 402. The accompanying text describes the desire to erase the 'barrier between the art work and the living community [through a] garden approach for the display of sculpture' and its interior equivalent, the open plan, which provided unprecedented spatial freedom. The text emphasized that the building was a single large area, which allowed for 'every flexibility in use'[11] – something now achievable with the modern structural type of the steel frame. Flexibility would become the *raison d'etre* and hallmark of Mies's pursuit of universal space. Notwithstanding the elegance of this system, Mies also developed his interest in the long-span industrial shed as an alternative spatial model. His museum incorporated a fragment of such a structure, for the roof of the auditorium, where two steel beams running above the roof plane support the shaped acoustic ceiling within 403. Mies turned directly to the long-span structure, however, in designing the Concert Hall.

In coming to America, Mies must have been struck by the prevalence of long-span light-weight steel structures. He must have recognized in the discourse on economy, speed and flexibility so many of the ideals that he himself had helped promote in the early 1920s. Already a popular form of industrial construction prior to America's entry into World War I, the long-span shed with its the uninterrupted floor area became the standard for manufacturing airplanes for the war effort. Savings in material and labour were appreciated, as were the virtues of welding. Articles in architectural journals treated the design of factories as more than pragmatic problems: they represented architectural and aesthetic opportunities. 'America Lives by Steel', declared one advertisement for the Youngstown Sheet and Tube Company of Ohio in the February 1938 issue of *Progressive Architecture*. Another ad, for the Bethlehem Steel Company, in the March 1940 issue of *Architectural Record*, as well as full-length articles in these and other publications emphasized the freedom and flexibility in use afforded by long-span, open-web steel joists for garages, airplane hangers and manufacturing plants.

As he often did with new ideas, Mies began to explore the clear-span pavilion through his teaching at IIT. In 1942 he suggested to a student, Paul Campagna (1917–2010), that he find a photograph of a very large space, perhaps an industrial structure, and then transform it into a concert hall for 3,000 people by hanging acoustic partitions. Campagna worked with an interior image of the Glenn L Martin Aircraft Assembly Building in Middle River, Baltimore, Maryland. Built around 1938 by Albert Kahn (1869–1942), the structure had appeared in journals as well as George Nelson's 1939 monograph on the architect, which Mies owned 406.[12] Mies suggested Campagna enlarge the image of the building to 1 metre (3 feet) and use the technique of collage, cutting and pasting paper to create acoustic partitions and thus making a room within the otherwise undivided interior space.[13] The result was later repeated with minor variations by other students and collaborators and held the germ of all the clear-span pavilions that Mies would go on to design, from the Cantor Drive-In project to Crown Hall, the Mannheim Theatre project (1952–3), Bacardi Building project (1957–61), Chicago Federal Centre (1959–64), Toronto-Dominion Centre (1963–9) and New National Gallery in Berlin (1962–8). Mies's own version of the photocollage 407, more than 1.5 metres (5 feet) long, placed a grey plane on the floor to mark the audience area, hung a white acoustic plane above it and wrapped it with a combination of straight and curved free-standing walls in yellow, brown and black. In the foreground Mies placed a sculpture of a seated figure by Aristide Maillol (1861–1944), which was later replaced with one of an Egyptian scribe.[14] Comparing this collage of the Concert Hall with his subsequent long-span pavilions brings into focus the techniques that he used to transform the shed from 'a given' into a work of *Baukunst*.

In his design for a drive-in restaurant located on a commercial strip in Indianapolis, Indiana (1945–8), Mies brought the structural trusses to the exterior of the clear-span building 410. Having earlier probed the possibility of external structure – in the IIT Student Union project and then again in the Museum for a Small City – Mies now made it the central idea for the project commissioned by Joseph Cantor, a successful businessman, theatre proprietor, film distributor and art collector. As hundreds of drawings in the Mies Archive attest, he laboured over the design, which was never realized. Cantor had initially approached Mies to design a bowling alley and also commissioned a house design from him, which remained unbuilt, of which there are also many drawings 411–414.[15] The roof of the Cantor Drive-In is a thin plane hung from the bottom of two long trusses and concealing its own structure within, even though that structure is integral to the stability of the trusses above it. The roof plane forms the ceiling of the interior at the same time as it extends beyond the glass box to create sheltering overhangs, which he would develop in later projects 408. Walls of varied heights demarcate different areas within the restaurant: low and intermediate walls for seating areas, and full-height walls for portions of the kitchen. The chairs Mies imagined were his own MR10 cantilevered chairs, designed in 1927.

Giedion once called the Eiffel Tower a body without flesh. Mies's project recalls images of skeletal structures such as those that populated the scientific literature in his library. The drama of the gesture was accentuated by running the two 46.3 metre (152 foot) trusses longitudinally rather than across the shorter span, which would have been more conventional and economical. As a result, the trusses are heroic in scale and support a large neon sign to produce a Constructivist image that would have been striking from the highway 409. Cantor had called for a strong identity from the road. Moreover, the trusses



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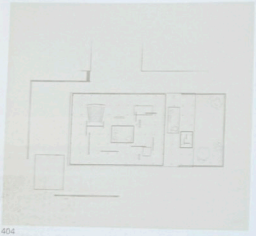

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403 Mies van der Rohe, Museum for a Small City, no site, 1940–3; sketch elevation and section showing exoskeletal truss on the roof and hanging acoustic shell

404 Museum for a Small City; plan

405 Museum for a Small City; photocollage

406 Albert Kahn, Glenn L Martin Aircraft Assembly Building, Baltimore, Maryland, 1937–9; interior view of the 90 metre (300 foot) clear span trusses

407 Mies van der Rohe, Concert Hall Project, 1941–2; photocollage

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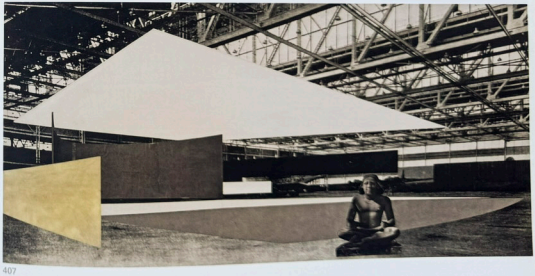

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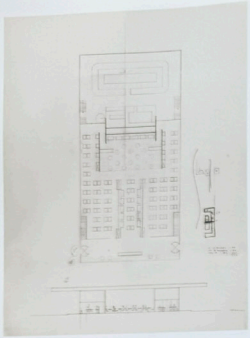

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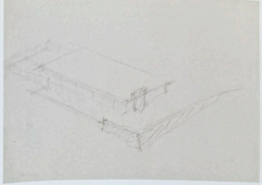
408 Mies van der Rohe, Cantor Drive-In, Indianapolis, Indiana, 1945–8; plan for kitchen and restaurant and elevation

409 Cantor Drive-In; perspective sketch with illuminated standard and roadside sign

410 Cantor Drive-In; night view of model



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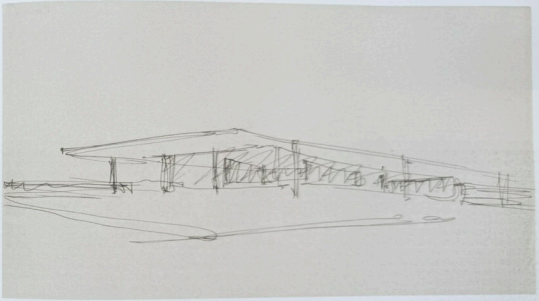

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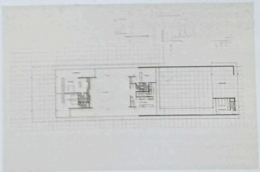

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411 Mies van der Rohe, Cantor House, Indianapolis, Indiana, 1947; aerial perspective

412 Cantor House; elevational perspective

413 Cantor House; perspective sketch from terrace

414 Cantor House; plan

415 Spread from Sigfried Giedion, *Bauen in Frankreich, Eisen, Eisenbeton*, 1928; shows the evolution of the iron and glass curtain wall from the Paris Exhibition building of 1878 to the the studio wing of the Bauhaus at Dessau by Walter Gropius and Adolf Meyer, 1925–8

416 Charles Louis Ferdinand Dutert, Galerie des Machines, Paris Exposition, Paris, 1887–9

417 Peter Behrens, AEG Turbine Factory, Berlin, 1909–10; interior of main hall

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are constructed from rolled H-sections using the new technique of welding rather than bolting, which produced a cleaner geometry and lighter structure. Although it was typical of industrial buildings to bring light into the interior through skylights, Mies never used them, preferring to capture light exclusively through the perimeter, in concert with visual transparency. From the outside the building was entirely transparent, putting its interior life on public display, whereas from inside, it provided expansive panoramic views in all directions. As the night view of the model emphasizes, the openness to which Mies aspired was extreme. Largely unprecedented in the industrial vernacular – although the garage doors of the Glenn L. Martin Aircraft Assembly Building did open one entire side – this would have been Mies's contribution to the emerging vernacular of the Strip. As Liane Lefaivre pointed out, Mies was proud of the project and presented it alongside more highbrow projects in his retrospective at the Museum of Modern Art in New York (MoMA) in 1947. Even before the Cantor commission, he had engaged the commercial dimension of American vernaculars as a juror in a storefront design competition, which recognized projects for their exuberant signage and contribution to commercial image.[16] When Roy Kroc opened his first McDonald's restaurant in Des Plaines, Illinois in 1955, it featured extensive glazing on three sides, shielded by a roof plane that was suspended from two structural arches.

With the Farnsworth House of 1945–51, Mies married the tectonic language developed through the IIT buildings with the idea of the unitary space of the clear-span pavilion inaugurated by the Concert Hall and pursued in parallel for the Cantor Drive-In Restaurant. Upon meeting Mies at a dinner party on Chicago's North Side, Dr Edith Farnsworth (1903–1978) described her desire to build a weekend retreat for herself and guests on property she owned in the countryside outside Plano, about a one hour drive west of the city.[425,17] Beginning in 1945, as construction was being completed on the Navy Building and Metallurgy and Chemical Engineering Building, Mies worked intensely on this small house for about a year and then took it up again a few years later, once the client had arranged financing. He applied the idea of an all-glass living room, developed for the Hubbe House (1935) and Ulrich Lange House (1935), to the house as a whole. Like the Resor House (1937–43), it was a simple rectangular block hoisted into the air, now with glass as the sole enclosing material extending the panoramic view to 360 degrees 419, 422. Myron Goldsmith, having trained as a structural engineer prior to studying and working with Mies, served as project architect and worked closely on the methods of construction as well as the structural calculations. Mies featured the project, not yet in construction, alongside the Cantor Drive-In in his MoMA retrospective 421. Construction began in September 1949 and was complete by March 1951, the same year the apartment towers of 860–880 Lake Shore Drive were completed (1951). With these projects and Goldsmith's help, Mies left behind the brick expression of the IIT campus to develop the architecture of steel and glass that came to define his later work and approach to the expression of structure.[18]

Mies set the modern yet rustic pavilion parallel to the banks of the River Fox on the edge of a woodland opening onto a field of tall grass 426, 427. By placing the steel columns on the exterior, in front of the roof and floor structure and even forwards of the glass, the steel took on prominence in the image of the building, notwithstanding how little steel was actually used 418. On an open porch placed at one end of the house the floor and roof extend beyond the last column, reinforcing the visual priority of the steel frame. Since the site is located within a flood plain, Mies extended the steel members to form stilts, which raise the floor 1.6 metres (5 feet 3 inches) above the ground. Little did he know that storm water created by subsequent development along the river would, by the late twentieth century, push flood waters well above the levels anticipated in the 1940s. Notwithstanding Mies's efforts to safeguard the house, it has flooded on several occasions, requiring extensive restoration.

During the first phase of design, Mies quickly developed the idea of a frame comprised of rolled-steel sections, some of which were concealed in the roof and floor plates while others were exposed, notably the

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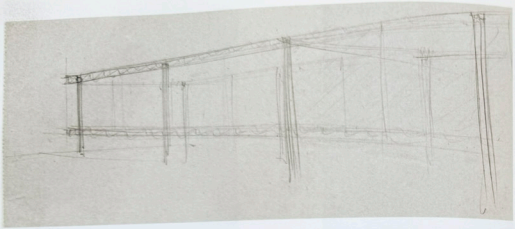
eight H-shaped, wide-flange columns and the C-channel fascia of the roof and floor plates. Sketches reveal that he considered different ways of cantilevering the horizontal planes, an issue which was ultimately resolved by connecting the cross-beams to the edge-beam to form a plate that could be extended at both ends, thereby lessening deflection at the centre. Initially conceived as a bolted frame with a concrete floor and terrace and a core of plywood and gypsum plaster, the house became – during the final stage of design – a welded-steel structure with a floor of Roman travertine and a core clad in primavera wood 420, 423, 424. In order to keep the heavy floor from deflecting, Goldsmith devised 'something very clever structurally'.[19] He later recalled, 'The roof and the floor edge channels are the same weight. They're very heavy, called car building channels, and the window mullions, that centre division between two columns was actually a structural member tying the two together, so that the weight of the floor is borne partially by those edge channels on the roof.'[20] Even the bar-stock framing the large sheets of glass was welded to the wide-flange column and the horizontal channel flange to serve as a tension strut. Inspired by ordinary industrial structures, in the end every aspect of the construction was unconventional and cunning in order to achieve the formal and spatial simplicity that Mies desired, as well as the articulation of elements and assembly. The specifications prepared by the office demanded a new level of precision workmanship. The task of keeping the steel square and plumb vertically during the erection of the house proved difficult and took a long time. The process of using plumb bobs was very slow and unsatisfactory, so Goldsmith devised a very long level with which to true the columns as they were fixed and welded in place.[21]

Arriving along a path parallel to the river, visitors see the house first obliquely through the trees and then at a right angle as one turns to approach it. After stepping onto the lower terrace, hovering just above the ground, they finally arrive at the covered porch, which frames the view of the landscape on three sides 398, 428–432. Large panes of floor-to-ceiling glass form the enclosing membrane of the house – including the doors – and produce a remarkable degree of openness. Curtains once again constitute key elements; here, in natural-coloured shantung fabric, they enable the interior to be entirely open or entirely enclosed, providing both intimacy and privacy 433.[22] A compact central core clad in primavera veneer houses two bathrooms, kitchen cabinetry, fireplace and utilities. By locating the core off-centre, giving it a different material character and maintaining a space between it and the ceiling, Mies encouraged the perception of the interior as a single space. Through the asymmetrical disposition of the core he differentiated the spaces around it by size as well as function (entry/dining, living, bedroom, kitchen) and encouraged free movement. Like the Barcelona Pavilion, the floor is paved in travertine and the steel window frames are assemblies of bar-stock with reveal joints that articulate the simultaneous separation and co-joining of discrete, autonomous parts 434. Unlike the Barcelona Pavilion, however, the frames – like the structure as a whole – are not clad in chromium but rather painted white, producing a strong counterpoint to the natural surroundings. Mies reiterated his system of elemental detailing in the wood panelling of the core and the free-standing teak wardrobe. Two full-height panels of glass open at the corners by the entrance, like rotating planes, while two small windows low to the floor also provide air at the opposite end.

As both the Farnsworth House and the apartment buildings at 860–880 Lake Shore Drive were being built, Mies began work on his own school of architecture at IIT, SR Crown Hall (1950–6), which became his first realization at a larger scale of a unitary universal space, or great hall, and his first fully exoskeletal structure 458. Intended to also house the Institute for Design, founded by his colleague László Moholy-Nagy, it was initially conceived as a tall single-storey building with an internal column grid, similar to the Museum for a Small City and the German Pavilion for the Brussels Exposition, sitting on the ground, enveloped by a glass wall on a lower band of brick 441. The first drawing, a perspective rendering made for fund-raising in early 1950, shows a building that uses the language developed for the campus, although



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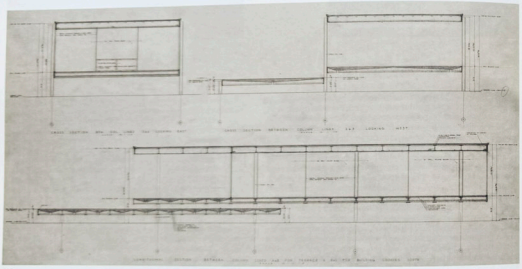

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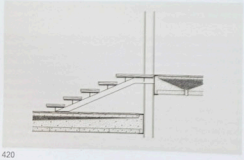

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418 Farnsworth House; perspective sketch showing house elevated on eight columns, emphasizing edge beams and transparency of the enclosure, 1945–6

419 Farnsworth House; cross and long sections

420 Farnsworth House; construction drawing of wall, floor and stair section

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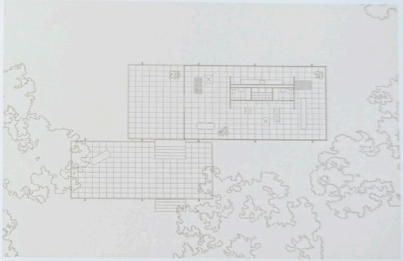

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421 Mies van der Rohe viewing the Farnsworth House model at the retrospective exhibition of his work at The Museum of Modern Art, New York, 1947

422 Farnsworth House; presentation plan, final scheme, 1951

423 Farnsworth House; detail plan of exterior columns and windows, 1951–6

424 Mies van der Rohe supervising laying of the travertine floor at the Farnsworth House, summer 1950

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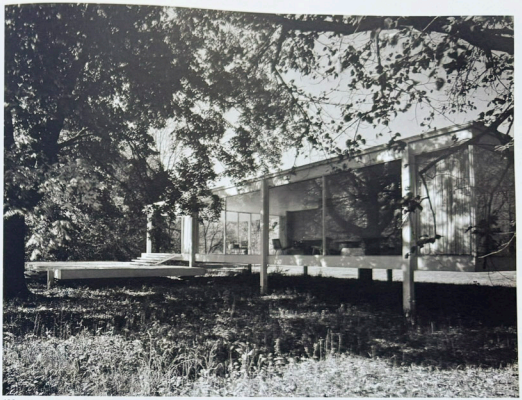

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425 Farnsworth House; view from across the River Fox

426 Farnsworth House; exterior view from southeast, with Edith Farnsworth's furnishings visible, 1951

427 Farnsworth House; exterior view from southwest

428 (Overleaf) Farnsworth House; view from the south

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429 Farnsworth House; view from porch looking into living area

430 Farnsworth House; entry area with dining table

431 Farnsworth House; living room

432 Farnsworth House; sleeping area with wardrobe

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adapted to reveal the unitary great hall with an unprecedented degree of transparency. As built, Crown Hall deviated from the rest of the campus more substantially, introducing a 3 metre (10 foot) building module, all glass enclosure, and long-span structural bay of 18 metres by 37 metres (60 feet by 120 feet) 435–437, 442. Its exceptional status within the campus is not merely a testimony to the importance that Mies might have assigned his school; rather it speaks to a fundamentally different approach to the education of architecture. It was built without classrooms and hence the need to conform to the 7.3 metre (24 foot) campus grid, which had been predicated on classrooms. There were also no lecture halls or faculty offices. Instead, Crown Hall offers 'one big room', as Mies put it, 37 metres by 67 metres (120 feet by 220 feet) by 5.5 metres (18 feet) high, surrounded by glass walls that were translucent for the lower 2.7 metres (9 feet) to shield the calm interior from outside activity while letting the sky provide a gently changing tableau through the upper ribbon of clear glass. A multipurpose area occupies the centre of the building, flanked on either side by open studios usually populated with rows of drafting tables. Just beyond the free-standing walls of this central space, stairs lead to the lower level, which housed the Institute for Design and now houses offices, workshops, the library and other support facilities 444. The life of the school is supported with minimal subdivision in order to maximize flexibility but also shared experiences – to see and be seen. Open to the main entrance, the multipurpose space is also open to the studios on either side and is typically used for lectures, exhibitions and other gatherings 445. Peter Carter, who worked with Mies in the later period, pointed out that within the single hall students at different levels were aware of all stages of the curriculum and could participate fully within it.

In an interview of 1958, Mies explained that the variable ground plan depended on what he called 'clear construction'. 'The variable ground plan and a clear construction cannot be viewed separately,' he said. 'Clear construction is the basis for a free ground plan.'[29] Elsewhere he called Crown Hall the 'clearest construction we have achieved'.[30] But why exactly was clarity so important? And what did it take to achieve it? Unfortunately, Mies himself never provided a direct answer; nor can his design practices be distilled into a single, simple or clear response. Certainly we could say that the expression of structure was an important ingredient of clear construction. At Crown Hall that meant placing the structure on the outside of the building – rather than on the inside – running plate girders above the roof and supporting them on H-section columns integrated into the perimeter envelop. Using a clear-span structure was surely also important for achieving a free ground plan, although a clear construction could be attained with other structural types as well, such as the high-rise skeleton and the low-rise repeated frame. Judging from the buildings, clear construction requires that an uncompromised, integrated and unified form be achieved, one that reveals itself not only as abstract geometry but also in its dependence upon a material system of construction. A clear construction implies the articulation of every element of a construction type or system, both in itself (as an individuated and separated element) and in its relationship to other elements (as part of a larger whole). Sharp outlines, smooth surfaces, precise lines, elemental geometry, harmonic proportions and reveal joints all contribute to produce not only the fact of clear construction but its appearance as well. It was in this sense that those who taught with Mies saw the didactic value of Crown Hall. 'What other school,' remarked Goldsmith, 'has a building where the students work in a building that is an embodiment of the ideas that are being taught.'[31]

Instead of the open trusses of the Cantor Drive-In, here Mies used plate girders 1.9 metres (6 feet 3 inches) deep, the surfaces of which have an elemental geometry of flanges and webs similar to the H-section columns, thereby enabling a single language of structure to be developed for using only horizontal and vertical planes 438. Joseph Fujikawa (1922–2003), who worked on the project, recalled that it may have been the exigency of making a quick model with solid strips of cardboard for the trusses that inspired Mies to use plate girders.[28] These suprematist bents appear less heroic than those of the Cantor Drive-In and run across the shorter dimension of the building. There are none at the ends of the building, accentuating the impression that the glass box is held within the structural armature and cantilevered beyond it 443. Instead of the five structural bays of the original scheme, there are only three larger bays, each of which is subdivided into six minor bays containing windows. These minor bays are formed with H-section columns welded to the horizontal beams of the roof and the continuous C-channel around the perimeter of the concrete floor; they protrude from the outer surface to create shadow and profile, just as do the I-beams on the curtain wall 438, 440. In the lower section of the windows, these bays are further divided into two. A broad platform hovers outside the main entrance midway up the stairs as at the Farnsworth House. Inside, an acoustic ceiling is hung tight to the underside of the roof structure and fills the box to the perimeter glass wall, where it is revealed as a hovering plane. Lighting strips and ventilators are crisply integrated flush with the acoustic panels. The floor is terrazzo with white and dark grey stones. Stairs are open holes to the level below, their railings reduced to tiny steel sections so that they almost disappear. Two ventilation shafts and utility chases run from floor to ceiling; they are finished in white plaster so as to be distinct from the language of structure and thereby avoid being mistaken as supportive piers. The oak panelled walls of the multipurpose space create a reception/office area facing the north entrance and storage closets.

Invited around 1952 to participate in a competition for a new building for the National Theatre in Mannheim, Germany, Mies produced another version of the long-span pavilion, this time confronting a need for more functionally determined rooms.[27] The program sought to combine opera and theatre on two stages. As Mies observed, this required spaces of two types: stages and workshops with large column-free areas and small rooms for many different purposes. He accommodated the former in an upper storey 12 metres (40 feet) in height, while the latter were organized in a lower level 4 metres (13 feet) in height. Overall the building is 80 metres by 160 metres (260 feet by 525 feet), with structural bays of 24 metres by 80 metres (80 feet by 260 feet) and a building module of 4 metres (13 feet) 447, 448, 450. Mies had concluded that 'the best way to enclose this complicated spatial organism was to cover it with a huge column-free hall of steel and coloured glass or, to express it differently, to place this whole theatre organism inside such a hall.'[26] To create the effect of a single large interior, all the enclosed rooms on the main level are located in the centre of the plan. Visitors stroll in a 12 metre (40 foot)-high ambulatory around this core, viewing the panorama outside at the same time as the internal operations of the theatre. This was a result of the fact that, as Mies explained, 'In the Mannheim building, stage and auditorium are independent of the steel construction. The large auditorium juts out from its concrete base much like a hand from the wrist.'[25] The two theatres – one at either end – are open to view from the ambulatory and even from the outside 451. With the main floor lifted above the ground, resting on low walls of green marble that extend beyond the building, the main auditorium itself becomes a stage visible from outside. The excskeleton once again features open trusses, which are 8 metres (26 feet) deep and run across the short dimension of the building. The fly tower protrudes above the roof as a small prismatic block and is barely visible from the ground. Earlier sketches and a collage for a theatre of 1947 show a more exuberantly shaped auditorium ceiling, transforming the hung plane of the earlier Concert Hall into a graceful arc 448, 449. The diagonal rake of the seating cantilevers boldly up in the opposite direction as a counterpoint. While curtains can be used to screen the interior, the spirit of the building is open, public, visible, even theatrical, albeit within a recessive architecture. When the client extended the competition into a second stage, Mies declined to participate further.

All of the projects discussed in this chapter employ similar techniques for articulating individual elements and their relationships, concealing as well as registering the inherent forces of their structure. The form of the elements and the constructive logic of the buildings as a whole are accentuated through the display of modularity, geometric abstraction, reduction, simplification of surfaces, sharpening of outlines and unifying harmonic proportions, as well as transparency and externalized structure. It was through these techniques of separating and

433 Farnsworth House; view of living space with curtains half drawn

434 Farnsworth House; view of detail at porch with window intersecting floor

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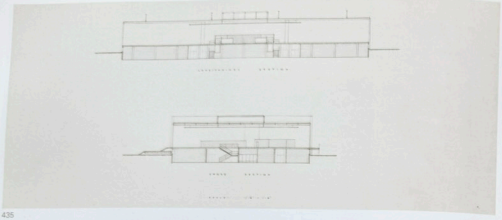

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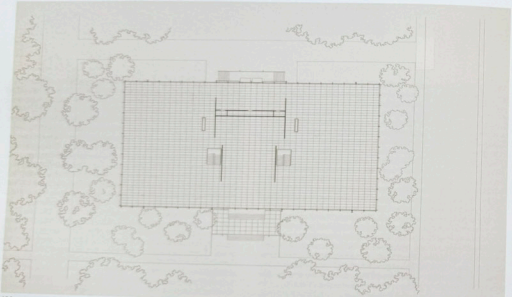

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435 Mies van der Rohe, IIT Architecture and Institute of Design Building (SR Crown Hall), Chicago, 1950–6; sections, 1952

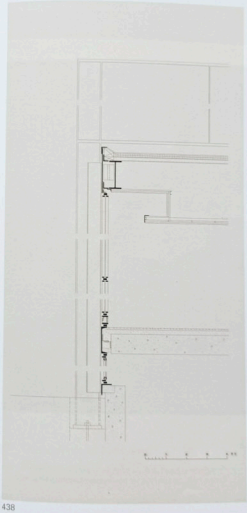
436 Crown Hall; presentation plan, 1953–4

437 Crown Hall; elevation

438 Crown Hall; detail wall section

439 Crown Hall under construction, 1955–6

440 Crown Hall; detail plan of perimeter wall



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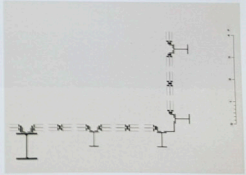

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441 Crown Hall; perspective for preliminary scheme, 1950

442 Crown Hall; view of main entry

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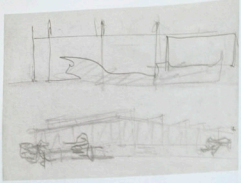
443 Crown Hall; exterior view of corner

444 Crown Hall; review of student work in Product Design program, lower level

445 Crown Hall; studios



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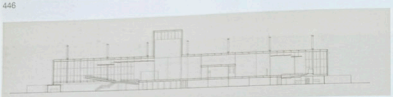

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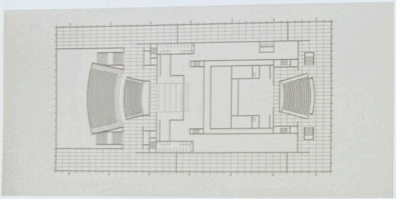

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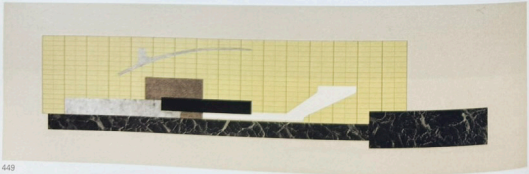

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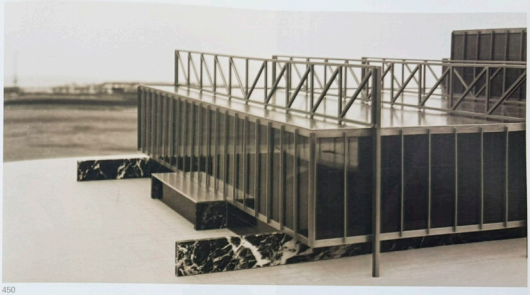

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446 Mies van der Rohe, National Theatre, Mannheim, 1952–3; sketch elevation and perspective

447 National Theatre; longitudinal section

448 National Theatre; plan

449 Mies van der Rohe, Theatre project, 1947; collage

450 National Theatre; model

451 National Theatre; elevational view of model

of Schinkel's Altes Museum

453 Albert Renger-Patzsch, photograph of the branching of a plant

454 Albert Renger-Patzsch, photograph of industrial cranes

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mathematizing architectural elements that building structures became art forms, symbols of structure in both the literal and cultural sense.

Mies's pursuit of a clear construction was linked not only to the reception of engineering amongst elementarist and constructivist artists during the interwar period but also to aspects of classical and Gothic architecture. Purifying surfaces, clarifying masses and regulating proportions were integral to the classical tradition, while externalizing, displaying and interpreting structure were constitutive of the Gothic. Whereas the classical achieved unity through symmetry and the conformance of parts and wholes, the Gothic employed repetition of motifs at different scales as well as in series. Mies was explicit in his admiration of both traditions. He collected books on both, visited the ancient monuments of Greece and reminisced about the powerful impact that the medieval Dom of Aachen had made on him growing up. Bringing aspects of these two architectures together places him, in fact, within a separate tradition – that of the Greco-Gothic, which was promoted by the Abbé Laugier (1713–1769) in the middle of the eighteenth century, realized by Jacques-Germain Soufflot (1713–1780) in the Church of Ste-Geneviève in Paris and pursued by John Soane in England and Karl Friedrich Schinkel in Germany. These proponents of the Greco-Gothic held that a new style of architecture would emerge through the fusion of the classical and Gothic, achieving the lightness, transparency and openness of the Gothic while incorporating classical elements. It was this spirit that Kurt Forster recognized when he wrote, 'Gothic tracery and classic framing interpenetrate in the facade of the Seagram Building to achieve a synthesis that had hardly ever been reached in the nineteenth century.'[30] This synthesis gave even greater emphasis to the organicist aspirations that had been part of both traditions, encouraging architects to see their art as founded in nature and extending its principles, forms and modes of construction.

Taking his cue from Schinkel, Bötticher had restated the Greco-Gothic ideal in the 1840s in a way that would still be resonant in Mies's work. While others of his generation debated whether the classical or the Gothic was more appropriate for the present, Bötticher held that they marked two stages of development, each of which had reached its fulfilment.[31] A third style, Bötticher observed, was destined to emerge as a higher stage of development, reconciling and unifying the two extremes.[32] It would require a new material like iron to provide the 'guiding principle' for a new system of covering and its artistic expression. 'It will have to be a material with physical properties that will permit wider spans, with less weight and greater reliability, than are possible when using stone alone.'[33]

Whereas Bötticher looked to the system of covering to provide the structural principle of every style, he looked to the material as the source of the structural forces that were the active principle of the style's expression. He considered 'relative strength (fracture)' to be the 'active principle of the Hellenic system of covering, and reactive strength (compression) that of the vaulting system'.[34] It remained for the new style to find an art-form compatible with the third and final structural principle – absolute strength (tension). For Bötticher, the new style's structural principle was to be adopted from the arcuated Gothic system and transformed into a new and hitherto unknown system; for the art-forms of the new system, on the other hand, the formative principle of the Hellenic style was to be adopted in order to give artistic expression to the structural forces within the parts, their correlation and the spatial concept of the whole. Only in this way would the right synthesis of the two preceding styles be achieved.[35]

Mies's long-span pavilions appear to answer Bötticher point by point. Employing steel – iron's successor, the strength of which in tension enabled extraordinary feats of engineering – Mies formalized a new covering system that achieved long spans. He articulated trabeated elements in ways that allude ever-so-distantly to capitals, bases, entablatures and porticoes. The articulated assembly and serial repetition of structural elements, which form such a strong aspect of Mies's buildings, were a common denominator amongst industrial structures, classical colonnades and flying buttresses, as well as plant stems,

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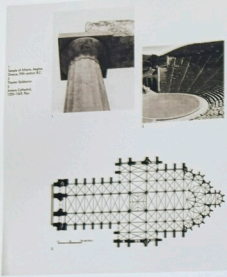
leaves and forests, as demonstrated in the folio of photographs by Albert Renger-Patzsch in Rudolf Schwarz's *Wegweisung der Technik* 452–454. Moreover, Mies gave the principle of tension extreme expression, allowing the roof structures to take precedence over the columns, the structural role of which appeared to diminish together with their mass. Mies's uniform and rhythmic treatment of the columns for Crown Hall, for instance, barely registered any difference between those that carried the primary beams and those located in between. The columns serve more to frame the space and neutralize the skin than to express their role in carrying the load of the roof.

Mies's expression of structure developed through a close collaboration with Goldsmith, who not only studied with Mies but worked on key projects where his approach to structure crystallized. Moreover, Goldsmith helped to disseminate this ethos in his teaching at IIT, where he often used historical examples to explain the principles of what he, and others, called 'structural architecture'. In drawing on history – non-Western as well as Western – he underscored that this constituted an important tradition with continuity across time and cultures, central to several (although not all) great architectural periods 455–457. In summarizing his teaching Goldsmith described structural architecture as 'a complex realm in the art of building in which architecture, engineering and aesthetics interact to make structure the central expressive element of design'. It embraced the principles of economy, efficiency, discipline and order, as well as formal coherence, 'in which the detail suggests the whole and the whole suggests the detail'.[36] In citing the classical tradition, he gave two very different examples, pointing first to the juncture of a Doric column with its entablature as both functional (transferring the load) and beautiful, and then to ways in which an amphitheatre expressed a pattern of organization, distributing viewers and optimizing sightlines and acoustics. Although the Gothic served as the strongest exemplar, Goldsmith also found structural expression in other places: in traditional Japanese architecture, with its emphasis on modularity, proportion and the free disposition of repeated elements; in engineering works and industrially based architecture of the nineteenth century; in the expressed structural frames of the Chicago School; and in the work of his two mentors, Mies and Pier Luigi Nervi (1891–1979).

The idea of the artistic interpretation of structure was indebted to Gothic architecture in another way as well. Historians of the architecture and art of the Middle Ages had drawn parallels between Gothic architecture and medieval scholasticism, with which Mies was deeply engaged during the last decades of his life. The most well-known and extensive treatment of this relationship was provided by Erwin Panofsky (1892–1968), in his book *Gothic Architecture and Scholasticism: An Inquiry into the Analogy of the Arts, Philosophy, and Religion in the Middle Ages*. Written in 1951, after Mies took up the design of long-span structures, Panofsky's book nevertheless provides the most concise interpretation of that relationship in his library. It serves to illuminate the scholastic themes that had, by the late 1940s, become integral to Mies's work.[37] Perhaps it even clarified the relationship for Mies, who had yet to produce his high-rise buildings, with their Gothicizing tracery and two-way spanning pavilions expressive of the roof structure both within and on the exterior.

Panofsky began by explaining that the parallel between scholasticism and architecture was a function of a shared *modus operandi* or habit of thought between the philosopher-theologians and architects who by the Middle Ages, had come to be treated as scholars and professionals.[38] Panofsky's account focuses on two fundamental principles of scholastic thought: manifestatio (elucidation and clarification) and *concordantia* (acceptance and reconciliation of contradictory possibilities). The former helps illuminate Mies's preoccupation with systemic articulation, whereas the latter speaks to the pervasive dualism in the architect's work, including the merger of classical and Gothic themes. Much of scholastic thought, Panofsky explains, revolves around the desire to establish unity of truth across faith and reason; not the reason of instrumental rationality but the attribute of mind that brings it in communion with the divine. Thomas Aquinas had



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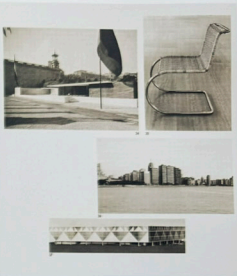
456 Myron Goldsmith, spread from 'Structural Architecture' in *Buildings and Concepts*, 1986; includes photographs of the temple of Athena at Aegina and the Theatre Epidaurus, and a plan of Amiens cathedral

456 Myron Goldsmith, spread from 'Structural Architecture'; includes Katsura-Villa at Kyoto, Shugaku-in-Villa at Kyoto, an Imperial Summer Villa, and Kintai-bashi Bridge, Japan

457 Myron Goldsmith, spread from 'Structural Architecture'; includes Mies's Barcelona Pavilion, 860–880 Lake Shore Drive Apartment and Convention Hall for Chicago



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suggested that human reason was able not to prove faith but to elucidate and clarify the articles of faith. Moreover, it could also be used to demonstrate its own operations. 'If faith had to be "manifested" through a system of thought complete and self-sufficient within its own limits yet setting itself apart from the realm of revelation, it became necessary to "manifest" the completeness, self-sufficiency and limitedness of the system of thought.'[39] The schematicism or formalism for which scholastic writing is well known was to elucidate the very processes of reasoning to the reader's imagination.

Systemic articulation was unknown until scholasticism. It introduced the division and subdivision of a book into sections, chapters, parts, members and articles, leading the reader, step by step, from one proposition to another, always informed of the progress along the way and often taking the form of dialectically subdividing concepts into two or more meanings. The principle of *manifestatio* consisted in making the orderliness and logic of thought palpably explicit, in 'clarification for clarification's sake'.[40] It was this passion for clarification that Panofsky said grew into a mental habit that extended beyond philosophy. 'The same obsession with systematic division and subdivision, methodical demonstration, terminology, *parallelismus membrorum*, and rhyme', he observed, became operative in music, visual art and architecture as well. Whereas music became 'articulated through the exact and systemic articulation of time', the visual arts achieved articulation through a similar division of space.[41]

Panofsky observed a correspondence between modern *Gestalt* psychology and the psychology of the thirteenth century, crediting perception itself with a kind of intelligence. Organizing sensory material into simple, 'good' *Gestalten* in 'an effort of the organism to assimilate stimuli to its own organization' was, Panofsky noted, 'the modern way of expressing precisely what Thomas Aquinas meant when he wrote: "the senses delight in things duly proportioned as in something akin to them; for, the sense, too, is a kind of reason as is every cognitive power".'[42] For Panofsky, the 'mentality that deemed it necessary to make faith "clearer" by an appeal to reason and to make reason "clearer" by an appeal to imagination, also felt bound to make imagination "clearer" by an appeal to the senses'.[43]

Richard Padovan has explored how Mies looked to Thomas Aquinas rather than Plato for his theory of knowledge. Mies often cited Aquinas's definition of truth as *adaequatio rei et intellectus* (truth is the correspondence of thing and intellect).[44] In an interview in 1961, Mies explained that he understood early on that the task of architecture was 'not to invent form' but was 'a question of truth'.[45] While Aquinas's dictum provided a guiding light, Mies explained that it still 'took [him] fifty years to find out what architecture really is'.[46]

Padovan pointed out that, rejecting Plato's doctrine of the latency of truth in the mind, Aquinas, like Aristotle, identified forms with their individual material manifestations. 'Our intellect,' he wrote in about 1256, 'draws knowledge from natural things, and is measured by them.'[47] Addressing the problem of how particular sense impressions are converted into thinkable ideas, Aquinas explained,

> Our intellect cannot have direct and primary knowledge of individual material objects. This is because the principle of individuation of material objects is individual matter; and our intellect understands by abstracting ideas from such matter. Now what is abstracted from individual matter is the universal. Hence our intellect knows directly the universal only.[48]

Unlike Plato's forms, for Aquinas these universals do not exist outside the mind, but rather are they identical with the form of the individual thing. Neither a property of the thing nor of the intellect, they appear only through a relationship of correspondence between them. Aquinas wrote,

> For true knowledge consists in the correspondence of thing and the intellect (*ratio veri consistit in adaequatione rei et intellectus*); not the identity of one and the same thing to itself, but the correspondence between different things. Hence the intellect first arrives at truth when it acquires something proper to it alone – the idea of the thing – which corresponds to the thing, but which the thing outside the mind does not have.[49]

As Padovan put it, 'Mies's architecture does not aim at universality in order to symbolize a platonic world of ideal Forms, but simply in order to be intelligible. Its whole intent is to state, as lucidly as it can, what it is and how it is made.'[50]

These ideas resonate with those of numerous other authors whose books Mies held in his library, who discussed sensation-based forms of cognition, especially in religion and art. For instance, Jacques Maritain, in his *The Range of Reason* (1942), explained that St Thomas was concerned with knowledge through 'connaturality' – that is, knowledge of a kind produced in the intellect, not by virtual of conceptual connections but rather by way of demonstration.[51] In his *Art and Scholasticism* of 1943, Maritain further linked this kind of cognition to the experience of beauty:

> In the beautiful that we have called connatural to man, and which is proper to human art, this brilliance of the form, no matter how purely intelligible it may be in itself, is seized *in the sensible and through the sensible*, and not separately from it. The intuition of artistic beauty thus stands at the opposite extreme from the abstraction of scientific truth. For with the former it is through the very apprehension of the sense that the light of being penetrates the intelligence.[52]

In a passage marked by Mies, Maritain underscores the importance of clarification for this kind of cognition:

> If beauty delights the intellect, it is because it is essentially a certain excellence or perfection in the proportion of things to the intellect. Hence the three conditions Saint Thomas assigned to beauty: *integrity*, because the intellect is pleased in fullness of Being; *proportion*, because the intellect is pleased in order and unity; finally, and above all, *radiance* or *clarity*, because the intellect is pleased in light and intelligibility. A certain splendour is, in fact, according to all the ancients, the essential characteristic of beauty … but it is the splendour of intelligibility: *splendour veri*, said the Platonists; *splendour ordinis*, said Saint Augustine, adding that 'unity is the form of all beauty'; *splendour formae*, said Saint Thomas in his precise metaphysician's language; for the form, that is to say, the principle which constitutes the proper perfection of all that is, which constitutes and achieves things in their essences and qualities, which is, finally, if one may so put it, the ontological secret that they bear within them, their spiritual being, their operating mystery – the form, indeed, is above all the proper principle of intelligibility, the proper clarity of every thing. Besides, every form is a vestige or a ray of the creative Intelligence imprinted at the heart of created being. On the other hand, every order and every proportion is the work of intelligence. And so, to say with the Schoolmen that beauty is *the splendour of the form on the proportioned parts of matter*, is to say that it is a flashing of intelligence on a matter intelligibly arranged.[53]

During the American years, Mies would condense such thoughts in the phrase attributed to Augustine that 'beauty is the radiance of truth'.[54]

In the medieval European world, the habit of clarification, Panofsky explained, achieved its greatest triumph in architecture. Just as high scholastic philosophy separated interior faith from (exterior) reason yet insisted that it remain clearly discernible, so in High Gothic architecture one could read the interior volume and even section on the exterior. The cathedral aimed at a totality that, like the scholastic *Summa*, would approximate the one perfect solution. It would express graphically the uniform division and subdivision of the whole following the principle of homology across scales and analogous relations amongst parts, such as the nave, the transept and chevet. At the same time, even the smallest part would be distinct, individuated and separated within the indissoluble unity: each rib from its neighbours, each shaft from the wall or pier to which it was attached. In this way, it should be possible to recognize the organization of the entire system from the cross section of a single pier.

Over the past several decades, scholars have come to consider Mies's expression of structure a bit of a ruse. While he exposed structure in