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FROM HEAT ABSORPTION TO SPECULATION: THE TROUBLED EVOLUTION OF INTERNATIONAL ALL-GLASS ARCHITECTURE IN MELBOURNE (1955-1985)

Generally, the paradigm of the international 'all-glass', 'glass box', or 'crystal box', in architecture is associated with the 1950s and 1960s. After World War II, in fact, several technological changes converged in new construction techniques of façades of glass and aluminium. At that time, the manufacturing epicentres of glass were in Europe and North America. Product making, science and building practice in glass technology reached Australia in the second half of the 1950s, when cultural affinities and commercial relationships were consolidated with the U.K. and the U.S.A. In Australia, the cultural heritage of many glass-clad commercial buildings of the period is recognised, but the technological and industrial events that influenced their fortunes - or misfortunes - are seldom considered in detail.

Using the lens of construction history, this paper revisits the development of commercial façades from the 1950s until the mid-1980s in Australia and, more specifically, in Melbourne. The local assertion of the 'glass box' style is considered vis-à-vis the global context of glass manufacturing, which in that period was subject to radical changes of global impact. This account is based on sources from the City of Melbourne Archives at the Public Records of Victoria, the Stephenson and Turner Archives at the State Library of Victoria and the Libbey-Owens-Ford Glass Company Archives at the University of Toledo in Ohio, U.S.A. Evidence from these sources is corroborated by information and advertising from American and Australian professional publications of the times.

Judging from the evolution of glass products and building applications in Melbourne after World War II, glass architecture reached its true 'golden age' in the 1980s. Between modernity and post-modernity, advancements in glass products stemmed from a continuous process of evolution. At the onset of the 1980s, the combination of product innovations, environmental concerns and new aesthetic stimuli brought to a strategic point of arrival in glass technology worldwide, thus creating far-reaching consequences for contemporary architecture and commercial construction. By contrast, the early curtain wall style of the late 1950s was only a preamble: an incomplete - and yet vital - experiment that resurfaced after three decades of latent technological progress.

Introduction

The development of commercial architecture in Australia has many parallels with North America. It is known that the two countries are linked by an enduring tradition of knowledge transfer set in the Pacific Rim, which started several decades before the modernist phase of the International Style.[1] The parallelism is multifaceted and includes many aesthetic and techno-cultural components, which are typically associated with the rise of business architecture after World War II.[2] The cultural and economic partnership between the United States of America (U.S.A.) and Australia is ascertained, but there is still scope for a broader investigation on the technological exchange between the two countries after World War II. In the U.S.A., a range of issues concerning the authenticity of modern curtain walls has been raised,[3] but the technological context of glass manufacturing and construction of the Australian counterpart has been considered less.[4] Building from inputs of the American glass manufacturer Libbey-Owens-Ford in Australia and focussing on the glass industry and all-glass architecture in Melbourne, this paper aims to bring to the fore new knowledge in the history of the techno-cultural exchange between the two countries.

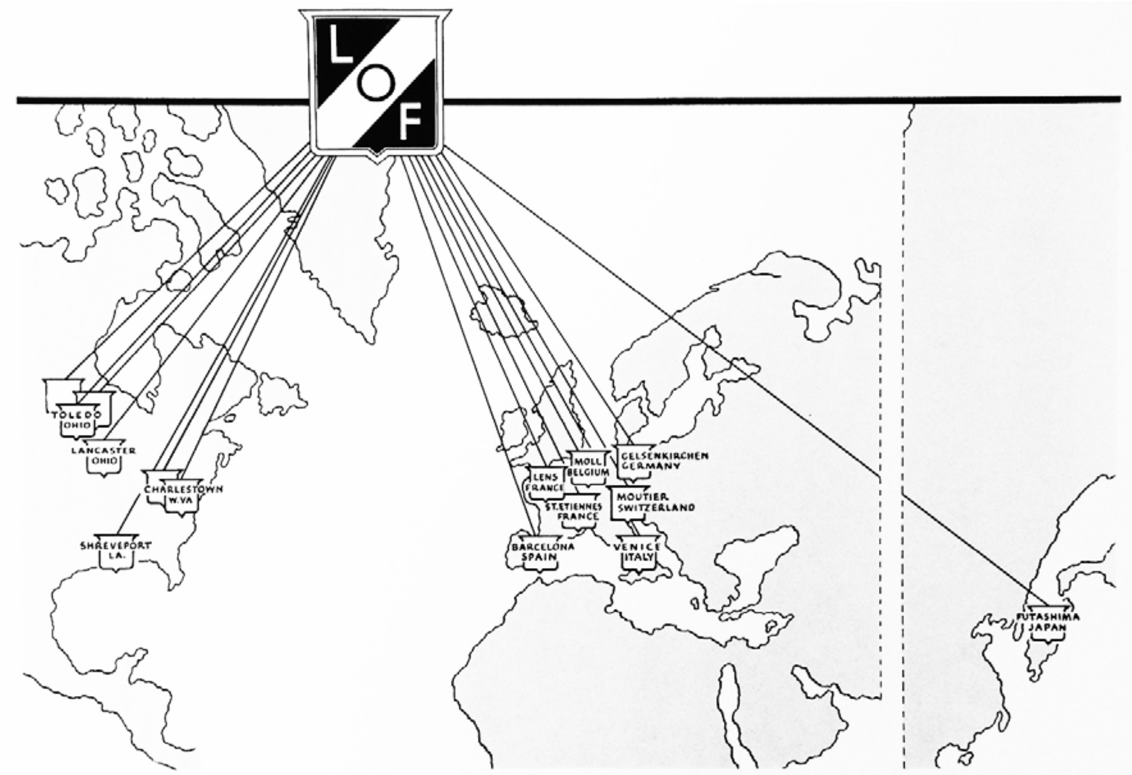

FIGURE 1 The global network of glass supply of Libbey-Owens-Ford in the 1930s (LOF Archives, Canaday Centre, University of Toledo).

Modern Glass: A Global Milieu

In order to discuss the technological evolution of international all-glass architecture in Melbourne, it is first necessary to summarise the development of glass manufacturing after World War II and to do so at a global scale.

At the beginning of the twentieth century, the glass industry was a global network of technological exchange led by capital-intensive and highly skilled manufacturing in North America, Northern continental Europe and the United Kingdom. After World War II, glass making revolved around the method of continuously drawn sheet glass, which was based on systems developed by Émile Fourcault in Belgium and Irving Colburn in America. Quality glass manufacturing was an expensive, globally competitive, sophisticated and risky business activity. Excellent transparency was achieved by eliminating superficial imperfections with costly investments in polishing machines. Polishing techniques were refined in the United Kingdom and in Belgium, where machines capable of "twin-grinding", which gave a parallel smoothing of glass simultaneously on two sides, were patented and sold for use under licence worldwide.[5]

In America, optical quality was demanded by the fast-growing car industry. Two large companies, the Pittsburgh Plate Glass Company (P.P.G.) in Pennsylvania and the Libbey-Owens-Ford Glass Company (L.O.F.) in Ohio, were the major suppliers of high quality flat plate glass for automotive use. In their home country, P.P.G. and L.O.F. constituted a giant duopoly, but since the 1930s they spread influence and business interests worldwide due to break-through innovations such as heat-absorbing glass, laminated glass and double-glazing.[6] (Figure 1)

By the 1930s, large-scale manufacturing innovations were established worldwide and, after World War II, glass manufacturers continued to invest in research to reduce production costs. L.O.F., for example, attempted to develop new methods to eliminate polishing and grinding, which depended from European patents. The Americans, however, were notoriously beaten in time once Alistair Pilkington fine-tuned the float glass system for the Pilkington Brothers Company.[7] Float glass was quickly adopted under licence by the American duopoly, but commitments to meet short-term shortages of polished plate glass delayed the domestic market response for this innovation in America. Pressed by demands from the automotive industry, the American manufacturers invested heavily in twin grinding with the result that only a limited a range of innovative products could be offered at a competitive price for the construction industry.[8] In the mid-1950s, American architects expressed concerns about the car-driven glass supply. Symptomatically, the variety of standard colours offered at the time by P.P.G. and L.O.F. were less than that offered by minor producers. By contrast, the affordability of standard clear plate, or 'pale blue' heat absorbent glass, was more economical for the emerging lightweight aluminium façades of the time.[9]

These market and industrial conditions contributed to create a generation of monotonous glass buildings, which is symbolic in particular of the American post-war modernist boom of the 1950s and 1960s and referred to as the 'glass box' phase of the international style. But, how did these international conditions interact with the Australian 'glass boxes' of the same years?

Glass Supply and Products in Australia

From the 1950s until the 1970s, P.P.G. and L.O.F. were key distributors of glass products in Australia. American plate glass products were imported by local suppliers, such as George Fethers & Co. and Henry Brooks & Co, and installed by local glazing contractors, such as Noel Searle and Oliver-Davey. In Melbourne, for example, the Shell Corner Building, which was one of the largest glazing projects of the late 1950s in Australia, was supplied with sixty thousand square feet of plate glass from P.P.G. (Figure 2) Later on, in 1969-72, B.H.P. House was also supplied with plate glass from Pittsburgh.[10] Records of the L.O.F. Company Archives show that American glass was supplied to several projects in other Australian cities, at least until the mid-1970s.[11]

Australian Consolidated Industries Limited (A.C.I.), a glassware company, which started originally in Melbourne, also produced glass in Australia. A.C.I. started to diversify into window glass in the 1920s and, from the early 1930s, produced glass for construction as Australian Window Glass (A.W.G.).[12] From 1961, using technical and financial assistance from Pilkington, A.C.I. opened a plant at Dandenong in Victoria and thereon, the Australian company initiated a long-lasting joint venture with the British manufacturer. In the early 1960s, news of the British success in the development of float glass reached Australia. (Figure 3, right) Pilkington's imports of float glass gradually filtered in the Australian market, and, in 1972, the first A.C.I.-Pilkington float line was opened in Dandenong, Victoria.[13]

FIGURE 2 Advertising of American made plate glass used in the Shell Corner Building, Skidmore Owings and Merrill, Melbourne, 1960 (*Architecture and Arts*, November 1961).

FIGURE 3 Left: Glaverbel plate glass advertising. Right: Pilkington float glass advertising (*Architecture and Arts*, December 1963)

Before the introduction of float glass, Australian projects adopted, by and large, the same technological solutions used in the United States. In the 1950s, Belgian glassmakers were also part of a worldwide supply chain and the company Glaverbel had a significant presence in Australia. (Figure 3, left) Glaverbel[14] was, however, partly owned by L.O.F. and distributed American products made under licence, such as L.O.F.'s pioneering double-glazed units Thermopane.[15] In the 1950s and 1960s, double-glazing was still in evolution and high costs and low reliability made it of limited - but not rare - application until the 1970s.

American single glazed heat absorbing products could offer transparency, mitigation of glare and provision of thermal comfort more economically than double-glazing. Heat-absorbing glass, developed in the 1930s by P.P.G., achieved thermal and visual performance through a body tint of grey, blue, bronze or gold, which was obtained with the inclusion of oxides such as iron, cobalt, copper and boron in the glass batch. Conversion of solar energy was carried in the glass thickness by absorption and heat was radiated inwards and outwards with almost equal intensity Heat-absorption mitigated thermal discomfort by filtering ultraviolet and infra-red rays and, furthermore, it reduced glare without compromising visible light transmission.[16]

Glazing Methods

After World War II, aluminium technologies and know-how of the aviation industry transferred to the civil construction sector and helped to diffuse curtain walls in the United Kingdom, in the U.S.A. and in Australia. In Melbourne, for example, the company Overseas Corporation Aluminium (O.C.A.L.), which during the war produced American and British aluminium aircrafts under licence at Fishermen's Bend, was instrumental for this cross-transfer.[17] During the 1950s and 1960s, therefore, progress in glass construction depended on interfacing issues with aluminium, a metal that was relatively new for the building industry.

Some properties of aluminium, such as ease of extrusion and good strength to weight ratio, made it ideal for framing systems, but another, namely the very different coefficient of thermal expansion than glass, imposed a process of experimentation. In early post-war curtain walls, problems of differential thermal expansion between glass and aluminium caused breakages and prevented adequate weather-tightness. Furthermore, extruded profiles took several years before reaching the technical milestones of today, such as pressure-captive glazing. Early glazing techniques in aluminium frames were based on traditional methods, such as oil-based putty, which soon proved inadequate for large glass panels. Subsequently, new glazing methods evolved through trial and error until soft petrochemical materials, such as Neoprene gaskets, became more available.[18]

Glass and aluminium brought architects to face new challenges of construction detailing. In the 1950s, lessons were learnt, for example, at Lever House in New York, where glazing compounds failed due to poor sealant adhesion and lack of tolerance and where wind-driven rattling of glass caused a number of panels to fall. Glazing methods and waterproofing performance improved thereafter with the introduction of polysulfide sealants like Thiokol, a compound that was developed during the war for sealing aircraft fuel tanks. Sealants of the new generation were more reliable than old putty, but, as two-part products, they were laborious to apply. Eventually, Neoprene rubber gaskets became the new standard and transferred the dry 'zipper' glazing technique used in car windshields to the construction industry.[19]

Aside from advancements in material technology, the morphology and the sequence of assembly of framing components was paramount. Early curtain wall systems relied on very simple traditional capturing methods with tee bars and internal glazing beads, which favoured glass installation from the inside of the building. This praxis changed in Melbourne at I.C.I. House, where glazing was installed from an external scaffold and where an aluminium channel was used as a bead mechanically fixed on the external side of a rebated frame. The glazing detail of I.C.I. House proved satisfactory in the longer term and it anticipated - although involuntarily - the weatherproofing strategy of drained joints, which evolved from the mid-1960s onwards and led to the pressure equalised façades of today. In tall buildings, however, glazing installation from the outside posed safety risks such as abseiling and working on dangerous external multi-storey scaffolding.[20] (Figure 4)

By the mid-1960s, the challenges of integration between glass and aluminium were resolved – particularly in America. In Melbourne, however, the modern paradigm of the "glass box" suddenly reached a point of no return due to issues of reliability that arose principally from problems of material integrity.

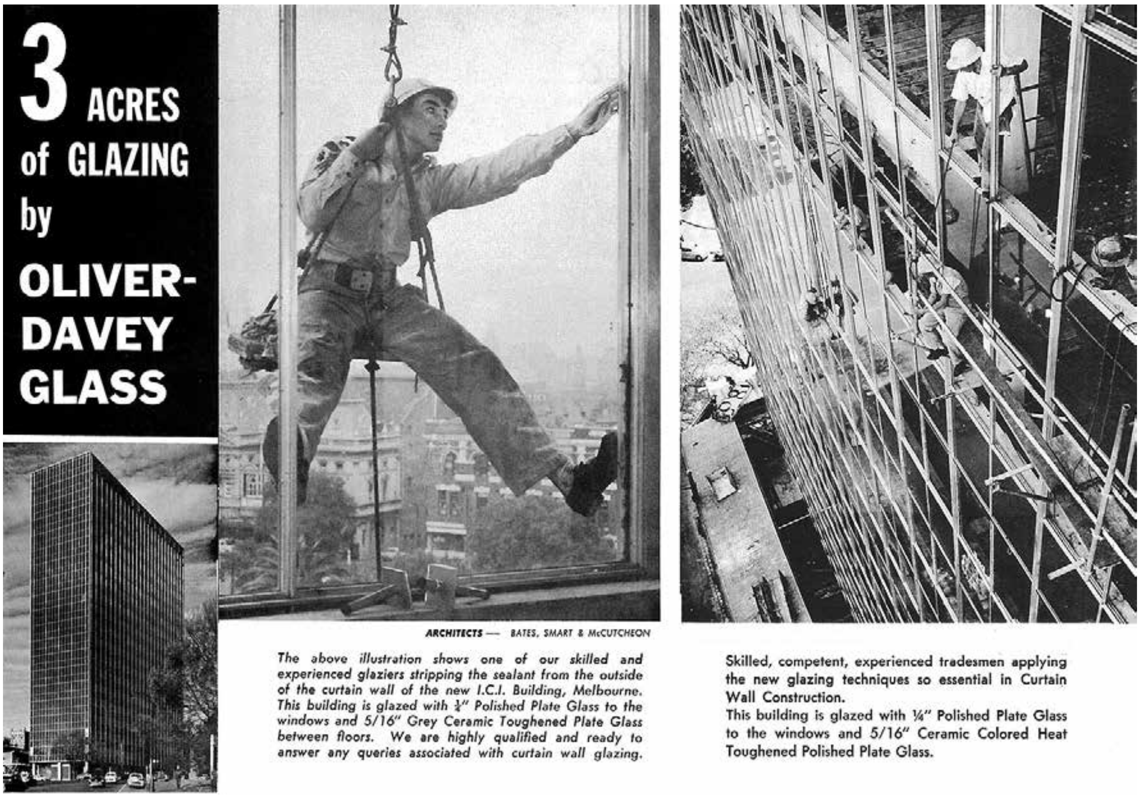

FIGURE 4 Advertising illustrative of glazing techniques used at I.C.I. House, Bates, Smart and McCutcheon, Melbourne, 1958 (*Architecture Today*, December 1958 and December-January 1959-60)

Lesson Learning

In Australia, the first troubles with glass quality were encountered with Crownlite, a ceramic-coated heat-absorbing spandrel made of annealed plate glass. Glass products of this type, produced by A.C.I., failed in two curtain wall projects completed in the mid-1950s, one in Victoria and one in South Australia. In July 1956, several spandrels of the office and canteen blocks at the industrial complex of the General Motors Holden (G.M.H.) Factory in Dandenong, started to crack. Failures occurred, without apparent cause, soon after the installation of Crownlite was completed. The broken spandrels were coloured ivory, grey, red and blue and they were immediately replaced. But breakage continued affecting a tenth of the façade. In the same year, a twelve-storey office block in Adelaide, clad with blue spandrels of the same type, was subject to a similar sequence of failures and caused a third of the spandrels to crack after installation.

Following enquiries on these episodes from Stephenson and Turner, the architects of the G.M.H. Factory, A.C.I. declined responsibility about material quality. In response to queries from the curtain wall contractors O.C.A.L. and Noel Searle, A.C.I. directed attention to matters of installation and suggested that, if lack of satisfaction was felt with Crownlite, contractors should source glass from overseas.[21] Facing these difficulties, Stephenson and Turner led an initiative to contribute financially towards a scientific investigation into the source of the problem experienced in the two buildings. With the aim to present a report on the causes of the failures, a study was commissioned to the Building Research Division of the Commonwealth Scientific and Industrial Research Organisation (C.S.I.R.O.).[22] A first technical inspection, identified that lack of adequate tolerance prevented thermal movement of glass panels inside aluminium frames - a problem which occurred also in American buildings, and which was considered to be a “major source” of cracking in heat-absorbing and coloured glass.[23] Thermal stress breakage in heat-absorbing glass was known in America since the 1930s and, following enquiries received from C.S.I.R.O., the Building Research Institute of the United States invited to send an Australian scientist to Washington to attend a state-of-the-art conference on glass and curtain walls.[24] C.S.I.R.O. appointed scientist Eric Ronald Ballantyne to undertake the study, and Stephenson and

Turner, and other project stakeholders sponsored the costs of the trip. From the American trip, Ballantyne brought back to Australia knowledge of latest curtain wall techniques and evidence of failures from case studies of seminal glass buildings such as Lever House and the United Nations Headquarters in New York.

In 1957, Ballantyne concluded a report on the cracking failures of Crownlite. The cause of breakage was identified on thermal stress fractures induced by steep temperature variations, which developed from the edge of relatively weak glass panes made of ordinary annealed glass. The report concluded with the recommendation to use toughened glass, a stronger material, particularly in heat-absorbing coloured spandrels subject to intense sun exposure.[25] In response to Ballantyne's report on the Crownlite failures, A.C.I. lamented that, notwithstanding the understanding of the origin of the problem, C.S.I.R.O. had not established sufficient knowledge to develop toughening methods on their range of coloured products. A.C.I. thus recognised incapacity to supply at short-term glass adequate for spandrel construction in Australia and the supply of coloured heat-absorbent spandrel panels in Australia diverted thereon to sourcing from overseas.

Cultural Banning

O.C.A.L. and Noel Searle, the glazing contractors of the G.M.H. Factory, were possibly instrumental for the introduction of toughened glass spandrels at I.C.I. House, where the builder E.A. Watts appointed them both as sub-contractors. The material selected for I.C.I. was blue, heat-absorbent, toughened Pan-O-Glass imported from Belgium.[26] The choice of toughened glass seemed best practice to prevent thermal breakage, but it turned out to be source of further plights in need of scientific investigation.

Since the opening of the building in 1958, a number of spandrel panels of the western façade of the I.C.I. House started to break and fall. The general contractor, E.A. Watts, was forced to install a protective scaffold over the footpath of Nicholson Street and, by 1962, the breakage took a disquieting situation with seventy-one façade panels fallen. The problem went back into the hands of Ron Ballantyne, who set to investigate the causes of breakage. Ballantyne found that the failures of I.C.I. House were unrelated to thermal stress. The cause was a different mechanism of rupture: the presence of unstable impurities of nickel sulphide in the glass batch, a vulnerability typical of toughened glass, which C.S.I.R.O. had earlier recommended to use to prevent thermal breakage.[27]

The new episode became a landmark case study and attracted 'considerable interest' for the scientific understanding of the mechanics of spontaneous breakage of toughened glass. In May 1962, all the seven hundred panels of blue-tinted Pan-O-Glass of the western façade of I.C.I. House were dismantled. The iconic building, celebrated only a few years earlier as the "first Australian skyscraper",[28] was left with a blank concrete wall sprayed by a waterproofing membrane coloured blue "to blend in with the other walls of the building".[29]

In the mid-1960s, commentaries on architectural and engineering periodicals argued to revise the trend to use largely glazed façades. Symptomatically, A.C.I. chose to envelope their headquarters in Bourke Street with a façade of precast concrete panels rather than with a glass curtain wall. In 1964, the journal of the Australian Institute of Refrigeration, Air Conditioning and Heating (A.I.R.A.H.) presented the winning scheme of the State Government Offices in Melbourne - a precast concrete complex advertised as the "the largest commercial air conditioning project yet attempted in Victoria" - and questioned: "more glass - or less for Australia?"[30] In 1965, Robin Boyd reassessed the praise for I.C.I. House, a building previously described as the anti-featurist paradigm of the international 'glass box'. A critical slant against the "technologists" emerged from the pages of Boyd's *Puzzle of Architecture*, where the critic claimed that no scope for "exploration and invention" was left in all-glass architecture.[31] In the late 1960s, John Maxwell Freeland put a critical seal on the "glass boxes", the "unspeakably dull" and unfitting "cellophane packages" of the 1950s.[32]

After the mid-1960s, Australian architects ultimately embraced the phasing-out of glass facades for reasons that went beyond those of a socio-aesthetic overhaul. As Freeland did not fail to mention, the short-lived phase of Australian curtain walls was brought to an end by a sequence of problems in weatherproofing, durability of seals, glass integrity and an inadequate climatic response, which was exacerbated by the unreliability of early air conditioning systems.

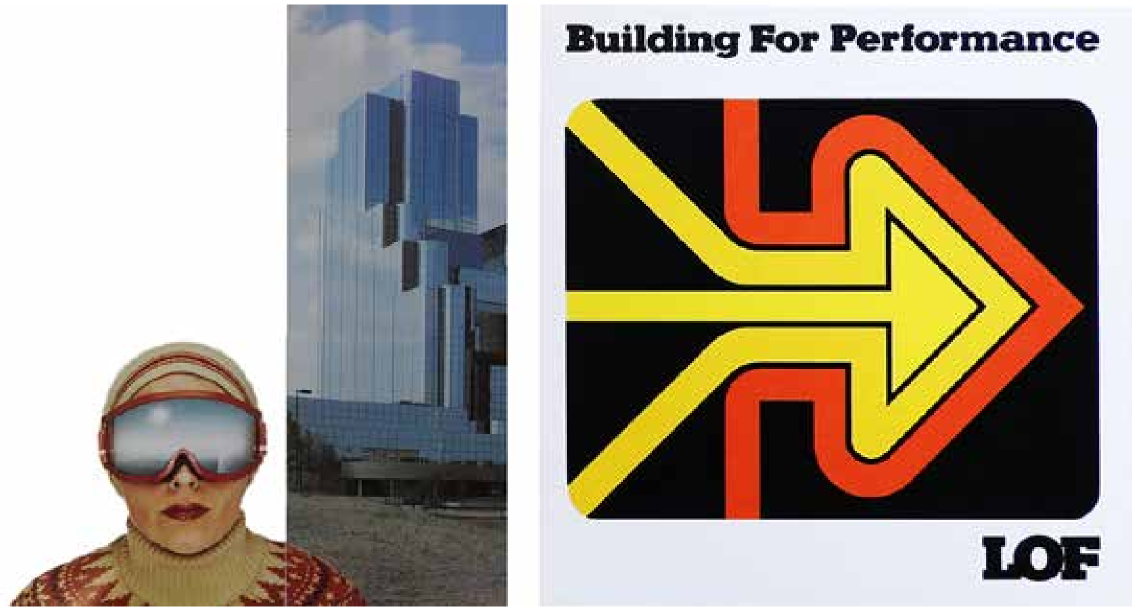

FIGURE 5 Advertising reflective and 'high-performance' glass in the 1970s (L.O.F. Archives, Canaday Centre, University of Toledo)

Time to Reflect

Notwithstanding building failures, the global glass industry continued to develop on two fronts of innovation. On the one hand, more efficient float lines progressively replaced plate glass production. On the other hand, higher performing products such as reflective glass phased out heat-absorbing glass. (Figure 5)

Reflective glass was first developed in the 1950s using films of thin chrome alloy bound by thermal evaporation. Early reflective coatings were used for indoors, such as L.O.F.'s Mirropane, a one-way transparent mirror. In a context of large demand and short supply of standard heat-absorbent glass, this technology remained in a state of research and development for at least two decades, but the socio-economic conditions of the Oil Crisis eventually provided the opportunity for American glass manufacturers to expand the market of reflective products.

Although the energy crisis was an accelerating factor for the market expansion of energy-awareness in glass products, glass manufacturers began earlier to respond to concerns about energy efficiency. During the 1950s, the glass industry faced higher performance demands coming from building owners that faced increasing air conditioning running costs.[33] Outdoor applications of reflective coatings were used in the inner side of double-glazed Thermopane units, which were also available in the Australian market.[34] In 1968, just before the 1970s oil crisis exploded, L.O.F. launched a new generation of glass products: Vari-Tran coated glass, which was produced with the futuristic technology of vacuum vaporised coatings. The American glassmaker promoted the new material as a "major promise to architects" and as a solution for energy saving concerns.[35]

In America, as a paradox, concerns for energy conservation grew in parallel with more - rather than less - use of glass. In 1972, talking at a round table on energy crisis organised by *Architectural Record*, Bruce Graham, the leader of S.O.M. in Chicago, predicted a shift in commercial architecture that did not exclude an ongoing role for glass:

> We have been heavily involved with 'all-glass' buildings. And we have, in these buildings, ignored the realities of nature. Rather, we have overcome the realities of nature by massive mechanical systems – by brute force. I think this approach to design is going to have to be reconsidered in favor of a new esthetic involving extensive sun shading and, probably, less and/or higher quality glass.[36]

FIGURE 6 All-glass office buildings used to promote reflective glass in America. Left: the IDS Tower, Minneapolis, Johnson and Burgee Architects, 1974. Right: Triangle Building, Atlanta, Thompson, Ventulett and Stainbeck Architects, 1976 (L.O.F. Archives, Canaday Centre, University of Toledo).

In the 1970s, taking environmental concerns as a pretext, a new generation of commercial buildings ensued in America. Using glass of better performance and innovative appearance, the emerging firm of Daniel, Mann, Johnson & Mendenall (D.M.J.M.) experimented with this new 'aesthetic system' in small corporate office projects clad in reflective glass. A new design sensibility stemmed from the concept of the envelope as a neutral, non-directional and centrifugal membrane: "the exterior skin does not reflect the organization of the interior functions. It is neither a structural system nor a bearing wall system. The lightweight skin enclosure, however, is a non-gravitational system - flexible enough to wrap around any function".[37]

By the mid-1970s, using highly reflective glass such as L.O.F.'s 'Thermopane Tempered Vari-Tran', a new paradigm of international architecture was established.[38] The neutral aesthetic of silver or golden reflective glass was the new global standard for office building, attested by the appearance of iconic skyscrapers and smaller campus-set office blocks alike. (Figure 6)

Dazzling Mirrors

In the 1970s, international reflective glass trends permeated gradually in Australia, but not without controversy. The new product was produced locally by A.C.I.-Pilkington,[39] but material imports from the United States continued to hold a market share.

L.O.F. advertised reflective glass in Australia and promoted Vari-Tran as the high performance glass "that cuts building costs" and that is "ideally suited to the Australian climate".[40] In the mid-1970s, L.O.F. supplied several Australian buildings with reflective glass. In Queensland the pyramidal Gold Coast Civic Centre was aptly clad with golden Vari-Tran, and in Melbourne, 71,000 square feet of silver Vari-Tran were used for Estates House in William Street. (Figure 7)

In 1976, L.O.F.'s marketing department enquired on the opportunity to use Estates House for promotional purposes, but the local supplier, Henry Brooks & Company, informed it that the owner refused clearance and preferred to keep a "low profile" on the identification of the glass.[41] The Australian supplier justified writing that the architect, in order to avoid "stirring up controversy", had carefully avoided any reference to reflective glass in planning permit applications.[42]

Reflective glass was indeed item of local administrative contention in Australia. Use of the new material sparked debate in Sydney and led the City of Adelaide to ban its use in the inner city.[43] Controversy originated from claims - supported by City Councils, but contested by others for lack of evidence - that reflective glass could cause additional heating costs to adjoining owners and injury to motorists. Objections arose, however, mostly from the offending 'specular effect' of glass rather than from empirical evidence of damage arising from reflected heat.

In the early 1980s, visual concerns about reflective glass reached Melbourne City Council and, in 1984, the City commissioned a report to determine an acceptable level of visible light reflectance. A survey of existing building in Melbourne's C.B.D. found that glass up to 40 per cent reflective was used in high-rise office buildings. A non-prescriptive guideline was established, where a maximum level of 20 per cent reflectivity or 40 per cent, subject to detailed assessment, was deemed acceptable. Citing sources from C.S.I.R.O., the study downplayed concerns about hazards to motorists. Ultimately, it found "visual light reflectance" an objectionable matter subject to "personal aesthetic preferences".[44] The City Solicitor contended that a proscription of reflective glass could not be lawfully upheld and that limitations on its use could enforced more likely on grounds of aesthetic "harmony" in areas of special significance, but hardly on grounds of "amenity". [45]

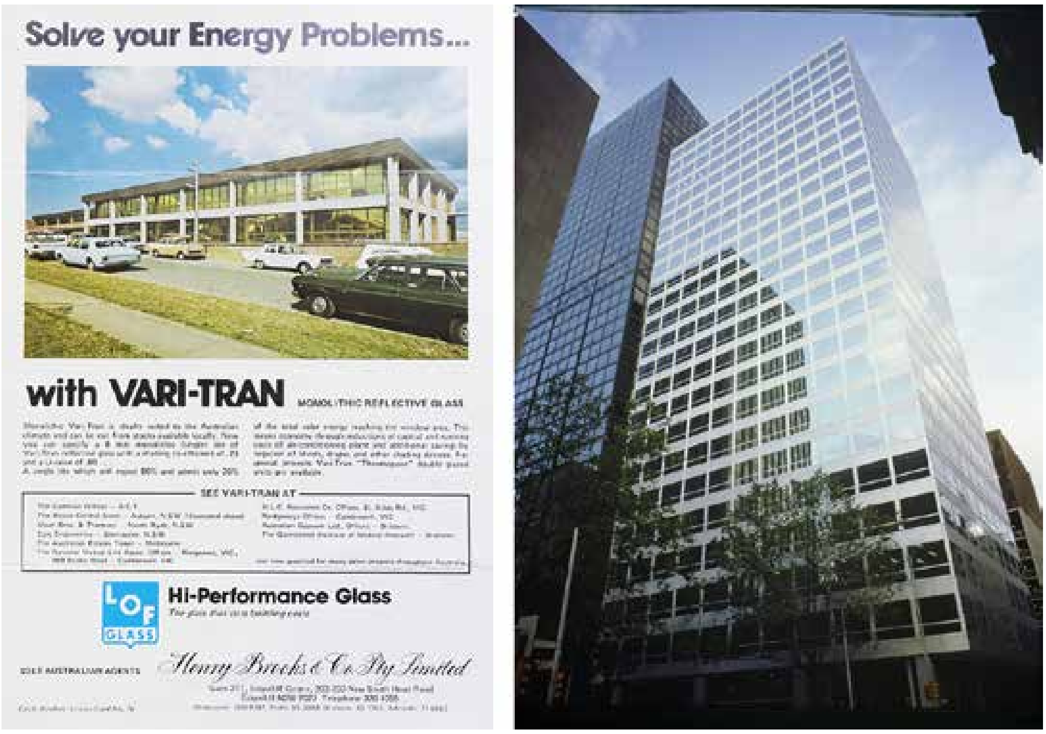

FIGURE 7 Advertising of L.O.F. Vari-Tran in Australia used at Estates House, Yuncken Freeman Architects, Melbourne, 1976 (LOF Archives, Canaday Centre, University of Toledo).

Controversy and tentative proscription, however, did not prevent Australian architects to experiment with the new aesthetic of reflection. The first wave of Melbourne's tall buildings of the 1980s opened with three office towers clad in reflective glass. A relatively small office building at 200 Queen Street, a speculative glass tower designed by Gerard De Preu and built by the emerging developer Grollo Australia, achieved quick commercial success and attracted as anchor tenant with name rights A.C.I.-Pilkington.[46] Real estate success was accompanied by critical praise. Even Norman Day, the architectural critic of *The Age*, who had earlier presented negative views on earlier 'glass box' architecture in Melbourne, did not fail to notice the novelty of the shiny curved office block: a glamorous, post-modern, "towering romance" that signified the end of the "horrible mistakes" of the "first skyscraper age".[47] In 1989, architectural peer recognition was given to 222 Exhibition Street, a finalist project of the R.A.I.A. awards shortlisted for the architect's (Denton Corker Marshall) ability to "slim down the stumpy proportions" of a square tower with four shafts of reflective glass.[48]

Conclusion

In 1985, Melbourne's reflective glass architecture reached its zenith at Rialto Towers. The grandeur of the project had no parallels in Australia. It was the tallest building in the country and the second tallest concrete structure of the world, only a few metres short of Chicago's Water Tower Place. The "sparkling" all-glass stick curtain wall was made of "Sky-on-Clear" 21 per cent reflective glass was supplied by A.C.I.-Pilkington.[49] (Figure 8) Unquestionably, as put by *Architecture Australia*, the new reflective skyscraper was a "new landmark" that gained unexpected popular appeal.[50] In the weekend insert of *The Age*, the journalist Keith Dunstan endorsed the new iconic building with awe-inspired fascination:

> Very early on, I decided I was going to hate the Rialto. As the central core went up, up, up at the rate of better than a floor a week, it was a great phallic symbol at the money end of Melbourne's Collins Street. […] Then came the indigo reflecting glass, creeping up floor by floor. […] Since then, along with many of my friends, I have noticed something else: it is Melbourne's Ayers Rock. In the early morning, it is deep pavement grey; as the light becomes brighter, it is all indigo. But then it can go white with the clouds, paler blue reflecting the sky. And magic takes over if there is any sort of a sunset. It becomes gold all over and some nights even turns to the colour of blood. Please forgive me: I repent. As an ultimate God-Preserve-Collins Street Greenie, I am beginning to love the Rialto. Heaven knows how anybody does any work in that building.[51]

The asymmetrically engaged towers of Rialto embodied a point of arrival in the history of Melbourne's glass industry. Less than thirty years earlier, following the spectacular debacle of I.C.I. House, glass was virtually banned in the city, technically and culturally. Failures showed the inadequacy of a regional manufacturer, A.C.I., to respond to a global market where American producers held a major competitive edge through product innovation. A.C.I., however, made the strategic decision to partner with Pilkington, and survived thereafter with the local production of float glass, while imports of glass from U.S.A. continued, however, until the 1980s.[52]

By storing heat inside the material, the early glass experiments of the 1950s relied on heat-absorption and failed to mitigate the heat-gains of the Australian climate. Reflective glass was the material that resurrected the 'crystal box' and liberated architects from the compositional chores of commercial building skins in a period of energy and cultural crisis. Reflective glass dematerialized and bounced off environmental inputs, but, as a paradox, these reflected themselves on the façade and reminded architects of the ineluctable priority to reconsider environmentally their designs.

From the 1950s to the 1980s, the changes recorded by all-glass office buildings reveal a *vulnus* that is characteristic of post-modern urban controls in Australia. Reflective glass was a material introduced *in primis* to conserve energy. But in Australian cities, and in Melbourne, the material became objectionable, first of all, on visual grounds due to the aesthetically offensive specular effects. By contrast, the popular appeal of the ever-changing, neutral and reflective skin allowed the tradition of the 'glass box' to resurface with post-modern flair and endure beyond the 1980s.

In summary, the architecture of the 'glass box' can be explained by a technological milieu that spans over the cultural distinctions of modern and post-modern. Glass in construction is the product of a global and sophisticated manufacturing industry that since the early twentieth century has established a worldwide network of supply and innovation. The evolution of glass manufacturing after World War II suggests that the techno-cultural genesis of all-glass architecture expands beyond the post-war boom. At the same time, the strategic steps taken forward by the construction industry from the 1960s until today can be measured and appreciated only in virtue of the problems, the experiments and the failures of that incomplete - and yet vital - period of high innovation.

FIGURE 8 Left: reflective glass advertising from Pilkington, 1985 (*Building Product News*, August 1985). Right: Rialto Towers, Gerard De Preu in association with Perrott Lyon Mathieson Architects, Melbourne, 1986 (G. Marfella).

Acknowledgements:

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Endnotes

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