STAINED GLASS:

An Investigation into the Design Potentials of an Architectural Material

by
Shirley Anne Ransom
Bachelor of Arts in Philosophy
Bates College, Lewiston, Maine
June 1972

Submitted to the Department of Architecture in partial fulfillment of the requirements of the degree of Master of Architecture at the Massachusetts Institute of Technology

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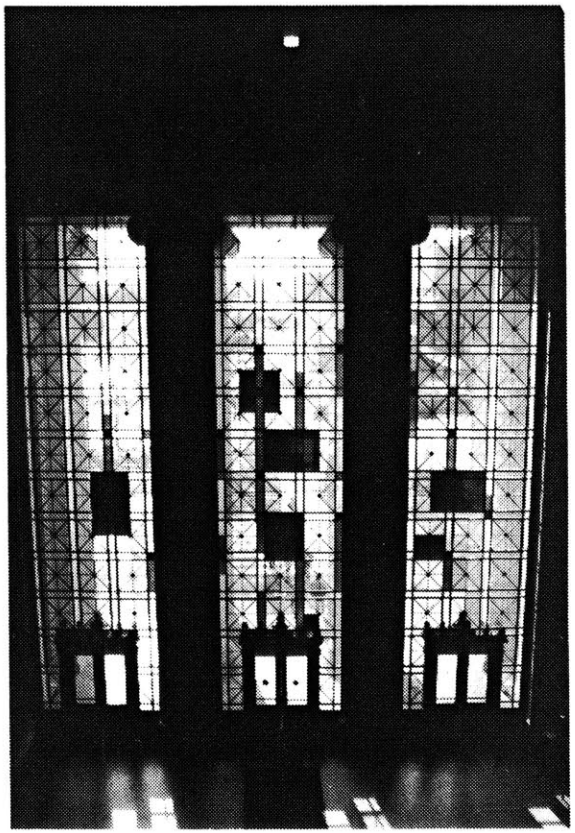
Signature of Author ___
Shirley A. Ransom
June 17, 1986

Certified by _____
Anne Wagner
Assistant Professor of the History of Art
Thesis Supervisor

Accepted by _____
Thomas Chastain, Chairman Departmental
Committee for Graduate Students



Abstract

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Colored glass is a building material usually associated with churches or days of bygone glory. Yet the material would apparently have much to offer in window openings, curtain walls, even as structural block in the creating of contemporary spatial environments.

The thesis examines two periods in architectural history -- the American Renaissance when the widespread popularity of stained glass was at its peak and the subsequent Modernist period when the use of stained glass was strongly questioned even in the bastions of ecclesiastical architecture. The context of architectural philosophy is studied to elucidate the qualities of the material as a design medium.

Two case studies from the 1880's, Trinity Church and the Yerxa-Field residence, are analyzed. A short sketch problem attempts to illustrate the findings by transforming a modern structure with the addition of stained glass.

Thesis Supervisor: Anne Wagner
Title: Assistant Professor of the History of Art

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Introduction

Many people have found themselves moved by the magic of a space transformed through the light of colored glass. At any scale, from a small window on a stair landing to the monumental misty atmosphere of Chartres Cathedral, a well-conceived piece of stained glass can often add an extra dimension to architectural spaces. Whether whimsical or reverent it has the possibility of making contributions that no other material can. As I thought about the subject it occurred to me that my own associations were of Victorian residences and church iconography. I began to wonder why my mind brought up no images of a modern secular idiom. The material seems far too delightful and expressive to be so neglected. Undoubtedly one limitation is cost, both of artistic design time and materials. However, even so, one still does not see stained glass used in corporate headquarters or important public buildings where special consideration is made for luxury or other particular statements.

The thesis attempts to explicate the design qualities and characteristics of stained glass as an architectural element. I will be looking at the material from the perspective of architectural use and not analyzing it as an artistic medium or going into any detail on craft techniques. The exploration will seek to discover the properties and uses of the material that may still be appropriate to contemporary architecture as a total built environment. Modern buildings, often accused of sterile efficiency, could benefit from the addition of colors and sur-

face textures. Modulation of light can be handled with different thicknesses, textures, and opacities of glass in combination. The elements of transparency and screen can multiply spatial effects beyond those of ordinary glass walls or window openings. And finally, the patterns and compositions achieved with shapes and lines can do much to influence the character of a space and reinforce architectural ideas.

To obtain a better understanding of these issues two distinct periods of architectural history will be investigated with regard to their prevailing attitudes toward stained glass. The American Renaissance (1876 to 1917) and the Modernist movement[1] (first half of the twentieth century) represent, respectively, a time of great infatuation with the material and conversely a time of its virtual disappearance. The arts, including architecture and the so-called decorative arts, are usually involved with the social and political contexts of their times. Design attitude and awareness is engendered and promulgated within these particular perspectives, emphasizing and minimizing different values at different times. These contextual differences highlight the different qualities and uses of stained glass as well.

Chapter Two will explore the "coming of age" search for maturity and identity which affected the architectural profession as well as its clients in the later part of the 1800's. The spirit of eclecticism and Renaissance values elevated many

arts to a new level of appreciation. Technical advances in machinery, processes, and chemistry promoted new possibilities both economically and artistically for stained glass. The Medieval craft was exhumed and expanded upon with great enthusiasm, but not without serious debate. Two case studies are analyzed to better illustrate the use of stained glass in a public building and a private residence. Design, color, placement, and size are analyzed to see how they affect the built spaces and further the architectural objectives of the building.

Just as Americans were finally enjoying some of the more sophisticated rewards of traditional civilization new building materials and new social needs began emerging which demanded a re-evaluation of the classical attitudes. The Machine Age, having had minimal impact on the building trades up to this point, began at last to be recognized for the opportunities it offered. Steel, reinforced concrete, plate glass, the electric elevator and industrial modes of pre-fabrication prompted new concepts in architectural expression. Chapter Three examines more closely the circumstances which effected changing concepts of space and form and the place of ornament in architecture. Attitudes toward stained glass were also reconsidered during this era and the chapter chronicles the insights of several different architects. Generally relegated to ecclesiastical settings at this time the craft was, however, the subject of several maverick notions which laid the groundwork for future

development.

Following the purifying effects of the modernists there has been a resurgence in stained glass in new directions. Originating in France and Germany since the 1940's a new field of colored glass artists has taken to heart the new architecture and the mutually complementary roles of architecture and architectural art. Chapter Four outlines the pertinent design qualities of the material as revealed by the preceding chapters' investigations and the thoughts of contemporary practitioners. A short illustrative sketch problem is used to clarify these points.

The Federal Reserve Building in downtown Boston was chosen as a typical example of sleek large scale corporate architecture. The sketch problem investigates a possible renovation of the huge glass lobby into a more humane and habitable human space through the introduction of stained glass. The objective will be to create guidelines for a glass curtain wall which contributes more to the interior space and the image of the building than the present sheer 140 x 35 foot clear unarticulated wall is able to do. The major design criteria of the material as discussed in the first part of the chapter will guide the project.

Illustrations for a topic such as this are severely limited by the required black and white xerox process of thesis reproduction. The full effects of stained glass on a space can only be appreciated in person on the site. In this sense even full

page color photos cannot convey the life of the material and the varying effects of light behavior. The reproductions in the thesis should be taken as helpful diagrams indicating starting points for further investigation. I urge the interested reader to garner whatever helpful insights he or she can from the writing and pursue them in the field.

American Renaissance

Our thoughts of Victorian and turn-of-the-century buildings easily include images of stained glass; but for some reason we do not recall it at all in those stark efficient structures of the first half of the twentieth century. What was so appealing about the material to the inhabitants of the 1880s and '90s and so wrong or abhorrent to the next generation? The period from the 1870s into the 1910s saw stained glass at its zenith in America. Stained glass panels and windows could be found coast to coast in private residences (from the palatial estates of the new captains of industry down to the middle class), in public buildings (from train stations to libraries), and of course in the ever-popular Gothic-style churches. It seems that before and after this period the material has been more or less relegated to ecclesiastical usage. Strong social forces were at work effecting this temporary embracing of the art; forces which came together, left their mark, and then were overcome by the next wave of cultural flux and response.

The Culture

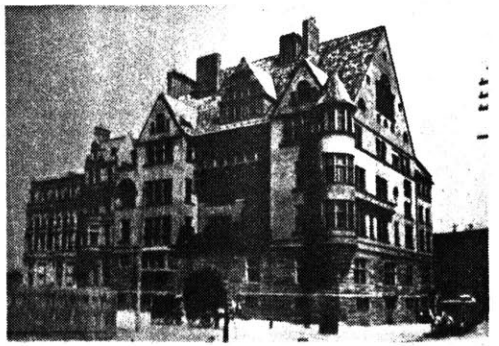
Crucial to an understansing of the architectural values of this period is an understanding of the social and political identity of the nation.[1] This was a time when America was coming into its own as a matured political entity. By the 1870s the frontier had been conquered; the West had been won and settled. North and South had had their strife and been knit

back into one nation. The Spanish American War in 1898 and the acquisition of colonies suddenly made the new nation a serious international political player. This was a period of consolidation and "taking stock" as opposed to preceding periods of exploration, expansion, and struggle for survival. America had reached a level of maturity and its citizens were eager to associate themselves with the trappings of civilization and authority. A potent force in the quest for identity and maturity was the Centennial Celebration of 1876 in Philadelphia. This naturally reinforced the feeling of separation from their forefathers and spurred a search for particularly American symbols. At the same time scholars had just discovered the concept of the European Renaissance as a historical-cultural event. Numerous books and articles appeared touting the virtues and achievements of the period and instigated a growing American infatuation. In their search for meaningful symbolic expressions of a great nation, American artists and architects began to turn to the classical and Renaissance past. As the architect and writer, Joy Wheeler Dow expained in his book, American Renaissance (1904): "We want to belong somewhere and to something, not to be entirely cut off by ourselves as stray atoms."[2]

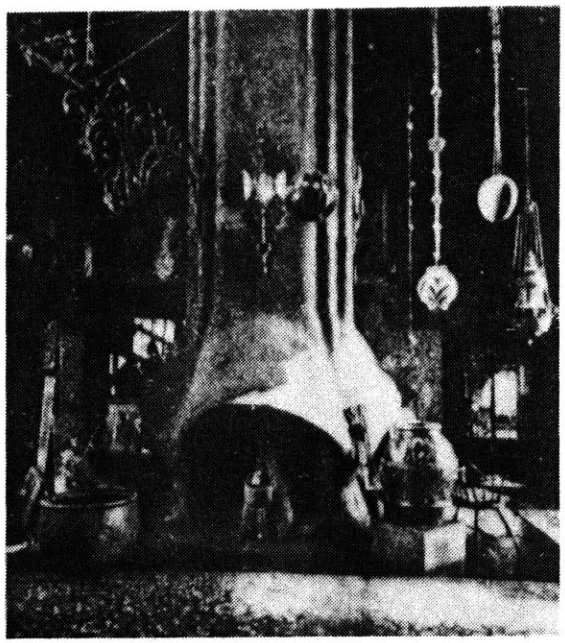
Life in both rural and urban America underwent great social changes at this time. In 1870 the national population was 39,905,000, which in 1910 grew to 92,407,000. In 1870 25% of the population was urban, while by 1910 urban migration

had swelled to 46% of the total population. This resulted in a five-fold increase in urban living from 9,000,000 to 42,000,000.[3] Along with such convenient technical inventions as the electric light bulb, the telephone, and indoor plumbing, it can easily be seen that most Americans were living under significantly different conditions than the immediately preceding generation of rural farmers. Organizationally, larger bureaucratic bodies were required to keep things functioning: corporations, assembly lines, and growing government bureaucracy. This upheaval of both physical and social life led to diverse visions of the American experience. Although there was a consolidating return to collecting the best from the past there also were the beginnings of an emergent modernism as expressed by such forerunners as Frank Lloyd Wright and Joseph Stella. The American Renaissance period really evokes more of a Spirit than a particular Style.

Not strictly traditional or authoritarian, the spirit was one of "cosmopolitanism," or we might say "eclecticism." This expanded attitude sought exotic and beautiful items of any origin and had the confidence to compose the eclectic and sensuous interiors of the period. For instance, in a single entry hall one might have found Roman sarcophagi, Venetian ceilings, large Chinese vases, a polar bear rug, and a stained glass transom.[4] Expositions, easier transportation, and a proliferation of books, periodicals, and photographs gave Americans the



2-1 Romanesque home of L.C. Tiffany, New York City, 1885.



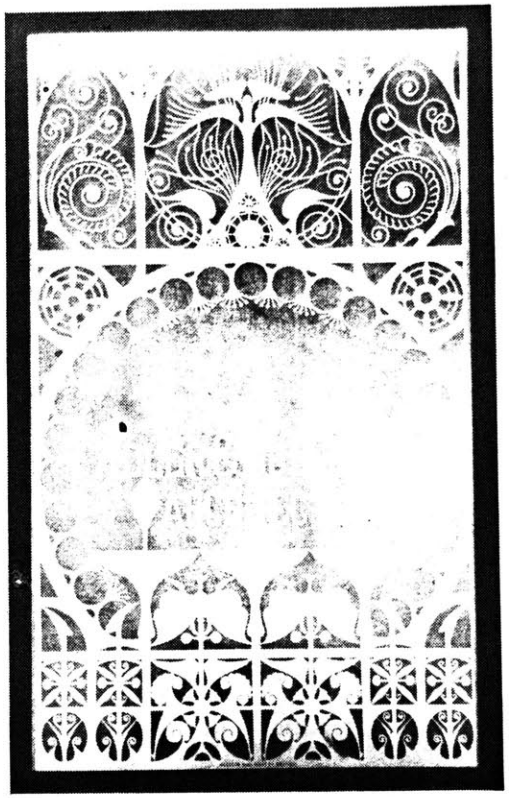
2-2 Tiffany's top floor studio.

opportunity to choose the best from all cultures and periods, Oriental as well as Western, our own as well as others. Together these epitomes would amalgamate to create a great new civilization here in America. The new wealth of American Industrialism permitted and in fact even demanded an image of culture and genteel idealism. The homespun vernacular culture was spurned in favor of an art and architecture with visible traditions and ties to a venerable past. The frontier struggle for mere survival had abated and made way for an enjoyment of ornamental richness and exoticism for its own sake. The aspirations of the wealthy and educated filtered down to the middle class by means of instructional books aimed at educating the homeowner and improving his or her taste and style. These books took a fairly moralistic attitude in eschewing the bad taste of the '40s and '50s and proclaimed that there was no further excuse for such failings.

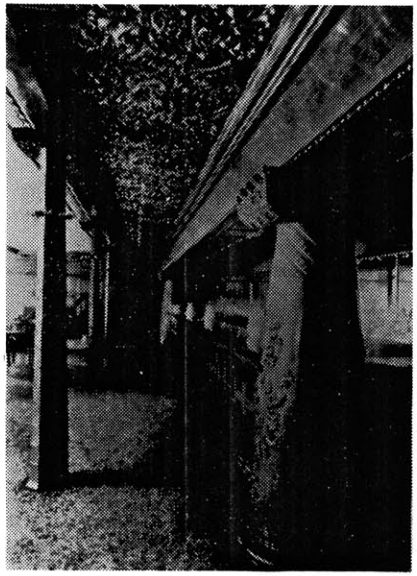
The Architecture

The practice of architecture was caught strongly and forcefully by the national struggle to come of age. It had traditionally been considered the lowliest of the professions, requiring neither great ability nor any particular schooling. There were no American architecture schools (M.I.T. being the first in 1865), and one learned simply through apprenticeship. Consequently the profession was prone to dilettantism and pri-

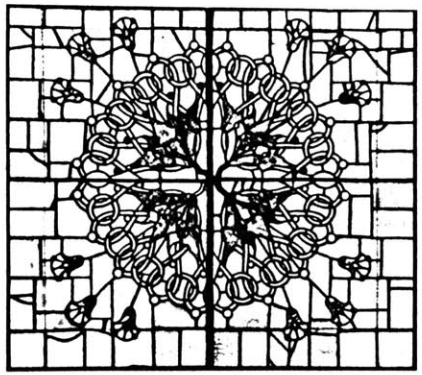
marily performed the functions of superintendent of construction. The Ecole des Beaux-Arts in Paris was the primary center for architectural training in Europe and promoted the practice of architecture as a coherent rational process with specific elements to be mastered and integrated. Architecture there was considered a monumental art which grew out of the traditions of the past and required murals and sculpture to complete its designs. Analysis of historical styles and the development of a particular vocabulary and grammar, as well as compositional rules (such as proportion, axis, symmetry, mass) were learned. By the 1880s H.H. Richardson, R.M. Hunt, and Charles McKim were the only American graduates of this prestigious formal training. Fortunately this began to change as more and more aspiring apprentices became exposed to the standards of other cultures. The Centennial Exposition of 1876 exhibited the best art work of many nations and made Americans aware of their lack of variety and formal training. One result was that American attendance at the Ecole des Beaux-Arts peaked between 1890 and 1914, concomitant with the founding of several other schools of architecture (and art) on native American soil. American architecture developed its own originality yet still maintained ties to Old World traditions and values. Choices of style and historic mannerism often reflected the individual architect's own personality and tastes rather than any didactic imperative. For instance, Charles McKim favored heavy restrained classicism of an almost



2-3 Sign of sand-blasted glass, designed by Louis H. Sullivan, 1883.



2-4 Auditorium Building, Adler & Sullivan, 1888.



2-5 Panel of green and rose glass from Auditorium skylight.

pompous nature, while his partner Stanford White was given to a more lively, highly-decorated and colorful eclecticism. It is notable that Americans were just learning to value a formal training and classicism as Europeans began to experience academic rebellion and the beginning rumblings of Modernism.

The word "decorative" has had negative, second-rate connotations in recent design history, being seen as something non-essential, impure, even distracting. But in the late nineteenth century the decorative arts (including mural painting, sculpture, stained glass, textiles, etc.) captured the attention of the most prominent artists and architects of the day. It was part of their self-image as "Renaissance men" that such notables as architect Stanford White also designed stained glass, fountains, wallpaper, jewelry, and magazine covers. The spirit of the Renaissance encouraged collaboration amongst artists in the creation of an enriched architectural environment that was the product of group effort rather than the lone crusading individual. Architecture was seen as the controlling art form in this effort, the three-dimensional object in which the other arts would be employed to create a unified decorative scheme. Richardson's Trinity Church (1872-77) is generally regarded as the beginning of this period of unified decorative ornament. Far from being considered frivolous extras, ornament was an integral element of the architectural ideal.

> In an age seeking a high culture, architecture provided the most permanent expression of the American arrival as a great civilization. The vituperation heaped upon the buildings of the American Renaissance by a later generation seeking the modern image is testimony to the power of these buildings.[5]

The Stained Glass

The venerable and majestic art of stained glass was ripe for a role in legitimizing the status of a rich and newly civilized nation. Many critics, both of the period and later, consider the medium to be one of the art forms which made the largest strides in development of both technique and style.[6] Europe, of course, had a long tradition of stained glass in its churches and cathedrals since Medieval times. What is sometimes less known is that builders in the Orient had also been using small pieces of colored glass which they inserted into carved holes in sheets of stone. Although the apertures were quite small they often were shaped into lovely designs and patterns. In America, stained glass had been largely absent for two reasons: the Puritan/Protestant ethic naturally shunned the flamboyant pageantry and icon worshipping of their Catholic counterparts; and secondly, there was very little colored glass manufactured in the New World and what there was was generally considered of poor quality. Some congregations had ordered windows from Europe but these were quite a burden to the pocketbook of a struggling young people. The resurgence of the Gothic

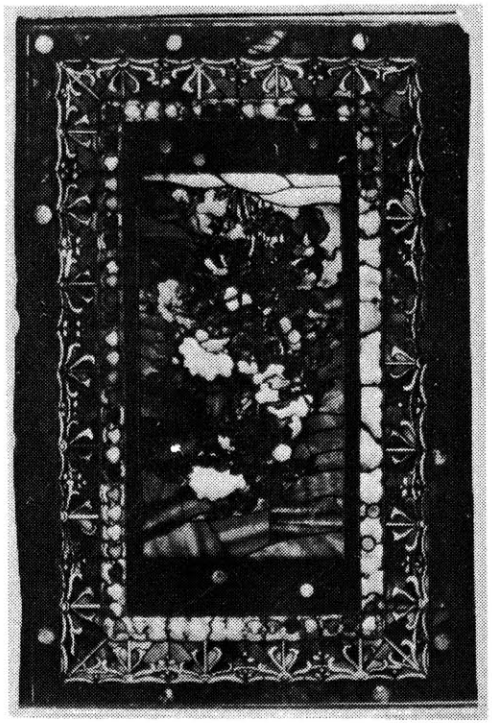
style of church architecture (both in Europe and America) was the prime mover in rekindling interest in colored glass windows.

Once the interest in decorative architectural element was sparked in the 1870s, stained glass began to be noticed as a material ripe for exploration and artistic expression. As in other fields a conscious effort was made to study the old techniques, to understand and reproduce them faithfully, and if possible to surpass them. Up to this time there were two craft traditions which had been developed in Europe. During the Medieval era, stained glass windows were constructed of relatively small pieces of clear colored glass held together by strips of lead, with the use of little or no paint. The ensuing Renaissance technique was enlarged by painting and staining on the glass surface and much more literal pictorial representation. This Renaissance style tended to predominate over the next few centuries although both attitudes had their adherents. During the American Renaissance a third technique can be credited to American endeavor. John LaFarge and Louis C. Tiffany developed almost simultaneously the new "opalescent" glass (or "American glass" as it was then called). This was an entirely new translucent material capable of giving dramatic new dimensions to the craft. Great debate raged amongst architects, artists, and artisans alike during the American Renaissance as to the appropriate uses and styles of stained glass. The full range of the artistic possibilities in stained glass were now

being exploited and challenged.

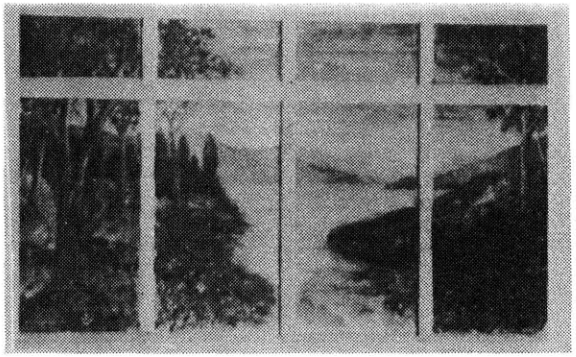
> Almost from the first day [stained glass designers] abandoned the usage and traditions of the modern European schools and aimed at brilliant effect rather than design, striving for artistic and harmonious arrangement of diverse colors rather than merely transparent pictures. So far has the American artist carried this feeling that he can no longer be called a painter on glass, but is really a worker in glass mosaic.7

At this point a brief discussion of some of the new methods and materials that contributed to greater possibilities in expression with stained glass is in order. In 1880, artist John LaFarge was granted a patent for the manufacture of an opalescent glass suitable for flat panel work and with the light-refracting qualities he was seeking (Louis C. Tiffany was also experimenting in this field but was not granted patents until a year later). Opalescent glass is a milky, multi-colored, translucent material with the iridescent sheen of opal and an almost opaque coloring. As opposed to the transparency and filtered, colored light effects of the traditional pot-metal glass, opalescent glass calls attention to the exaggerated textures and color variations of the glass material itself. Opalescent glass is much more stone-like and substantial in appearance. It does not have the shimmery, ethereal qualities of the pot-metal glass which is much more sensitive to changes in lighting conditions. The transparency and varying light modulations of the traditional glass make it more difficult to



2-6 "Peonies Blown in the Wind" by John LaFarge, c. 1879; one of the first works in opalescent glass.

2-7 Landscape design by Tiffany.



2-8 Landscape design for Mellon residence, Pittsburgh, 1912.

pin down its exact size and distance. Opalescent glass makes more of the glass itself as an immediate medium, while pot-metal glass functions as a light and coloring filter where the glass becomes somewhat de-materialized. The new glass encouraged the "painterly" approach to a window by keeping the picture plane intact and by giving more control over the intensity of light in a design. It also allowed an architect to fill large openings with a softly tinted opalescent glass which would admit some light without making a glaring hole or an abrupt interruption in the stonework.

The gas- and steam-driven machinery of the technological age made American production of both old and new types of glass economically feasible; they could now compete favorably with European imports. Modern chemistry enabled the American craftsmen to become infatuated with color more than their European predecessors had ever been. New colors invented in glass (apple green, opaque turquoise, sunburst, peachblow) were often gaudy, spurred on by the American obsession with the exotic arts of the Orient and the yen for sumptuous interiors. In addition to an expanded palette of glass, the designer also had new came materials available. The traditional pliable lead strips joined with solder to hold the pieces of glass were still most widely used but stiffer cames of zinc and copper were developed which made mass production of some designs easier and also required less reinforcement bracing against buckling. They were also very

suitable and conducive to the more severe geometric designs that became popular after 1900.

It was the emergent "Renaissance" idea of an overall decorative scheme which gave rise to a wider range of artistic possibilities inherent in glass. A revival of stained glass was a natural outgrowth of the interest in murals, mosaics, and harmonious color schemes. Unfortunately, architects trying to call for stained glass windows in their buildings found that they could "suggest" appropriate styles to their clients but that the windows, particularly those in churches, were often paid for by individual donors who insisted on their own tastes.

Many well-known painters of the day, such as Francis Millet, Edwin Blashfield, Kenyon Cox, and Robert Blum, designed windows. The two major stained glass artists of the period, LaFarge and Tiffany, both began their careers as talented and respected painters. LaFarge was sought widely for his architectural murals, and Tiffany executed canvases depicting exotic landscapes, flowers, and scenes from his travels. Tiffany, in particular, as a painter was intrigued with the workings of light (not unlike the European Impressionists) and no doubt this heightened his interest in stained glass. Both men found themselves drawn into the larger field of integrated interior decoration as a suitable outlet for their "Renaissance" capabilities and interests. After 1900 Tiffany's name began to be associated with his art glass furnishings even more than with stained glass

2-9 Window by John LaFarge, c. 1877.

2-10 J.J. Lefebre's oil painting "Girl Reading" was copied by Tiffany in glass.

2-11 "Oyster Bay" by L.C. Tiffany, 1905.

or glass mosaics. He was considered the most important and successful American decorator of the turn of the century working in the popular Medieval style. Criticism was sometimes leveled at the artistic merits of some of Tiffany's work (particularly as time went on), but one of his major goals was to provide good artworks to the greatest number of homes, not just to kings, churches, and millionaires.[8]

Debate abounded over whether stained glass as a medium was most suited to pictorial expression or abstract pattern; and further, if it were to be pictorial should the representation be flat or volumetric? Although initially treated as more similar to mosaic patterns, stained glass designs became more and more pictorial. This reflected the trend of the decorative arts in general to become more pictorial and based on historical precedent, but it also reflected the influence of the many painters who approached the medium with painterly agendas of their own. For instance, Louis C. Tiffany invented the landscape window scene; this imagery had never before been seen in stained glass. Even the European Renaissance artists with all their stains and enamels had essentially limited themselves to portraits and other iconic imagery that promoted the mysterious aura of early Christianity. The controversy is summarily disclosed in critical writings of the period. The painter and reviewer Roger Riordan wrote:

> Mr. Tiffany has shown that ... many of the most beautiful and poetic passages of landscape can be better represented in glass than in paint. Effects of rippled or quiet water, sunset and moonlit clouds, mysterious involutions of distant woods and hills....[9]

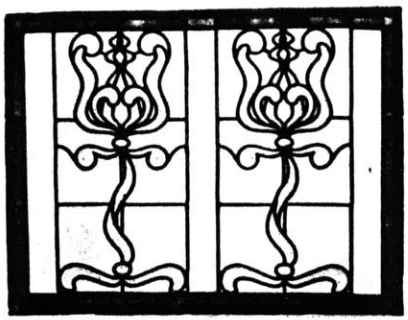
From the opposing camp, art critic and social reformer John Ruskin, in Modern Manufacture and Design, had this to say about the craft in general:

> No man who knows what painting means can endure a painted glass window which emulates painters' work. But he rejoices in a glowing mosaic of broken color; for that is what the glass has the special gift and right of producing.[10]

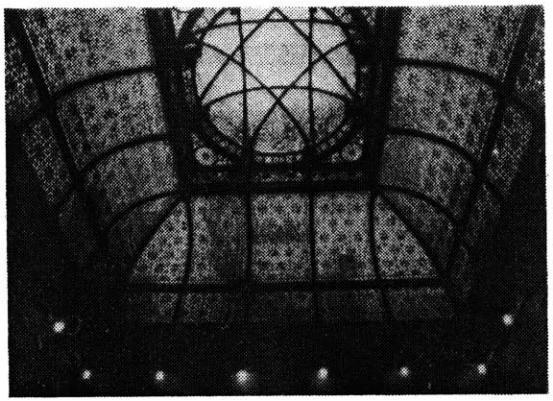
Critic Cecilia Waern, in one of a series of contemporary articles on American craftsmen of the 1890's, admired the quality and beauty of Tiffany's windows but felt there was no real need for

> ... elaborately designed pictorial windows with a material of this intrinsic value ... the results still leave much to be desired. The texture is too luscious, the treatment too pictorial, the designs not important enough. The work is a translation from a sketch; the medium still awaits the artist that shall make it his own. Mr. Tiffany has done his part in providing noble resources.[11]

The matter of colors was another area of attention for artists and architects alike. As previously mentioned, advances in the chemistry of glass production added many exotic new colors and textures to the window-maker's palette. While this yielded



2-12 Pomegranate design by architect Howard Van Doren Shaw, 1901.



2-13 Skylight in Samuel J. Tilden mansion, Manhattan, c. 1884.

expanded artistic opportunities, it also contributed to somewhat garish effects at the hands of lesser artists. Tiffany scorned those who relied on the safety of neutral tints and felt it was the responsibility of the artist to know how to use color:

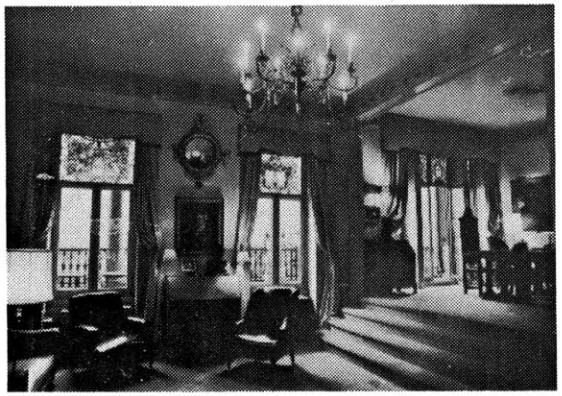
> The impression one gets is lack of courage, an obscure feeling that color is a danger; and perhaps that feeling is based on a real lack of temperament in the public and in workmen, which makes them unable to distinguish between deep, strong coloration and gaudiness. Perhaps it springs from a lack of naivete, a presence of self-consciousness which combine to depress and sterilize art. Certainly our climate invites to sumptuous color.[12]

Chicago architect Francis LeBaron cautioned against mis-use of the ever more popular artistic glass as it filtered down to the middle classes. He found it fitting for hallways and stairways and desirable for shutting out such unpleasant views as vacant lots, stables, and alleys. Rooms occupied by the family, particularly for working or reading, however, were totally unsuitable for colored glass, he felt.

> An artistic panel over a sideboard is very ornamental but our guests and friends are not improved in appearance by being seen with purple hair, or green noses, or yellow lips, or variegated foreheads. The vulgar combinations of cheap stained glass that are stuck into every window of every "flat" are simply abominable. They corrupt the taste, for by constantly looking at them we grow to like them.[13]

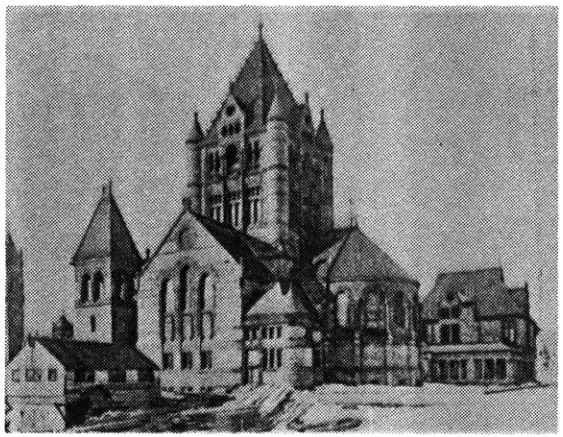
Despite all the controversy stained glass (along with other

forms of ornamental glass, including sand-blasted, acid-etched, and chipped glass) became enormously popular. Colored glass with serious themes was considered essential for important new public buildings. In residential use leaded colored glass appeared in transoms and in border panels around doors and windows. Themes were usually geometric or floral and often inset with pressed glass "jewels" or painted with birds, flowers, and insects. Large pictorial representations, previously used only in churches, began to appear in secular settings such as staircase landings and public spaces. Art glass panels were considered an appropriate way to block out the smoky skies and crowded streets of urban congestion. As popularity grew studios began to market "stock" windows with fruit and flower themes which could be purchased from catalogs by the square foot. Symbolizing art and luxury, transoms and domes of vibrant stained glass appeared even in the opulent traveling palaces of the Pullman Company railroad cars. Along with the soft plush seats and gilt chandeliers, even the poorest passenger felt temporarily raised to glory. The ambience moved Nathaniel Hawthorne to exclaim, "they spiritualize travel."[14]



2-14 Transom panels in the Reading Lounge of the Players Club, New York City, c. 1888, probably part of remodeling by Stanford White.

The following two case studies were selected to illustrate the preceding discussion. The historical context of each is discussed as well as my own evaluation of the contribution of the stained glass to the architectural objectives. Trinity Church represents use of the material in a public building; the Yerxa-Field house shows it being adopted within a private residence.

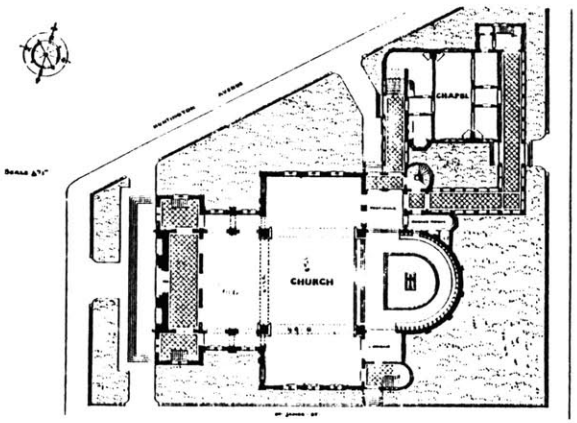


2-15 Trinity Church, Boston, 1872-77.

2-16 Yerxa-Field residence, Cambridge, 1888.

Trinity Church

Trinity Church is usually considered to mark the beginning of the American concern for a unified decorative scheme in architectural expression. As a young architect of thirty-four, Henry Hobson Richardson entered a competition for the design against a field of more established practitioners. He was awarded the commission in 1872 with a Romanesque design that was in sharp contrast to the prevailing Victorian Gothic style. Richardson felt that the small, triangular, highly visible site was more hospitable to a compact Greek cross plan with a central tower than a long axial Gothic nave with front or side spire. The massing of the Church established a fundamental pyramidal order with the tower emphasized as the dominant architectural feature of the interior as well as the exterior. The vast space of the centralized tower flanked by the short wings on all four sides symbolizes a spiritual uplift, a conduit of light and space between Heaven and Earth. The four great columns which



2-17 Plan of Trinity Church.

support the tower and grow up out of the earth emphasize the strength of this vertical connection to a divine power.[15]

Richardson was not a true Romanesque Revivalist but apparently felt free to shape his own style from many periods and precedents. In his own words:

> The style of the Church may be characterized as a free rendering of the French Romanesque, inclining particularly to the school that flourished in the eleventh century in Central France -- the ancient Aquitaine ... [which] developed in various forms a system of architecture of its own, differing from the classical manner in that, while it studied elegance, it was also constructional, and from the succeeding Gothic in that, although constructional, it could sacrifice something of mechanical dexterity for the sake of grandeur and repose.[16]

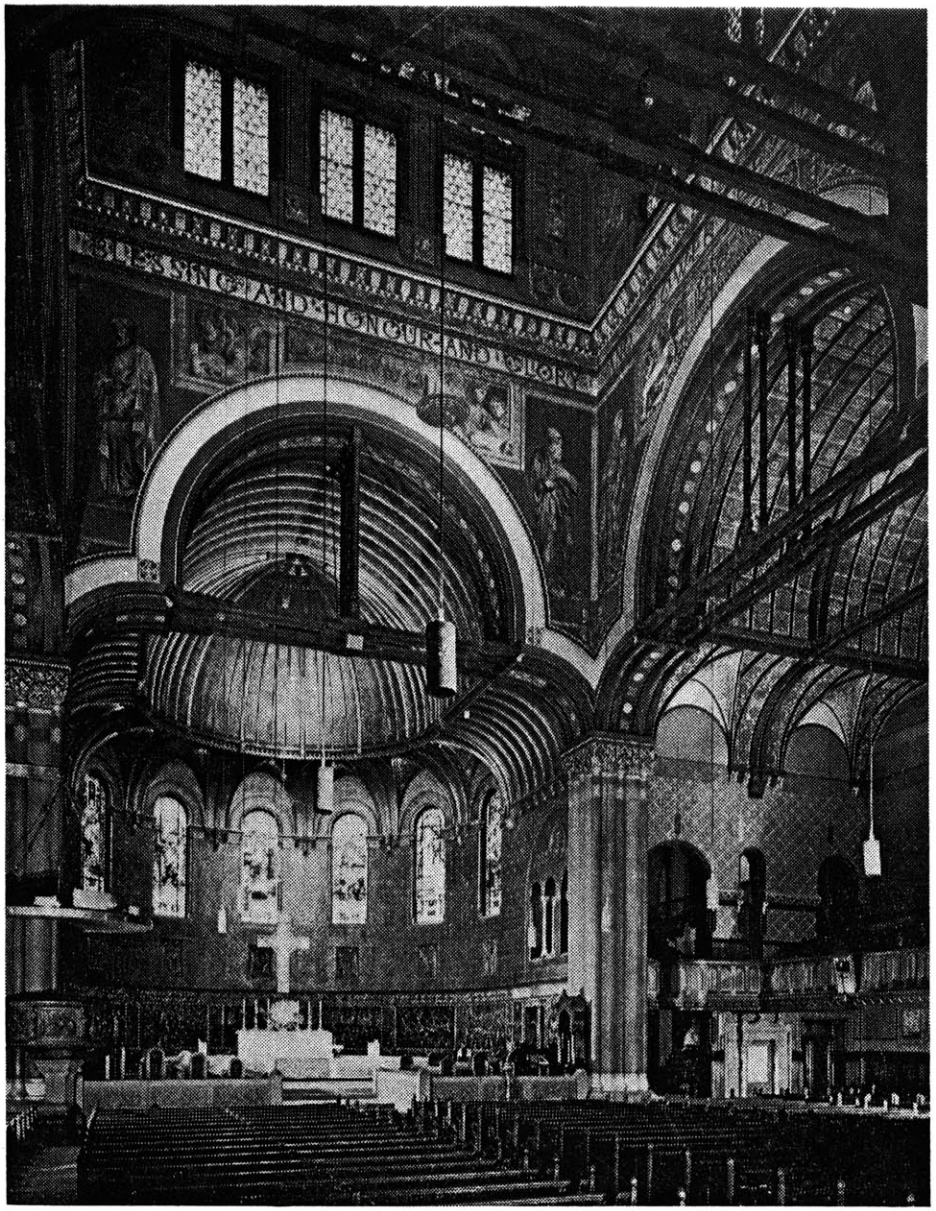
The tower was derivative of one on the Old Cathedral in Salamanca, Spain. The west porch (actually added twenty years later, but from Richardson's own sketches) was based on that of St. Trophime in Arles, southern France.[17] The church took five years to build and seems to have benefitted in richness from the layering of decisions and multiplicity of personalities at work upon it. Richardson allowed draftsman, artist, and builder to interact and influence one another, although he retained his own role as final arbiter throughout the evolutionary process. The smaller towers and the west porch were not completed in their present form until after his death, although their development was based on the master's initial ideas. This continual elabor-

ation by a community of builders and artists is what gives the structure its majestic intricacy.

Color was an integral element of Richardson's design concept for both interior and exterior. A light granite from several New England quarries was the major building material, and a red Longmeadow sandstone comprised the contrasting trim. Semi-glazed red tiles were ordered from Akron, Ohio, for the roof and louver boards, and special ridge ornamentation from Chicago. The interior particularly was meant to revel in a splendor of color. Although tempted to keep the structural integrity of the granite walls, Richardson decided that painted plaster was the best way to extend a pervasive use of color throughout. As he explained to the congregation:

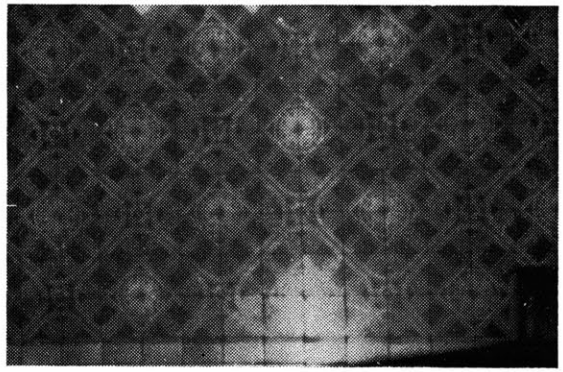
> A rich effect of color in the interior was an essential element of the design, and this could not be obtained in any practicable material without painting. Brickwork, which might have been strong enough in color, would not have endured the strain upon it, and the use of granite was a necessity of construction. The cold harsh effect of this stone in the midst of the color decoration could not be tolerated....[18]

The intense decoration of Trinity's interior space has been noted as marking "the break of the Boston mind with its Puritan tradition."[19]

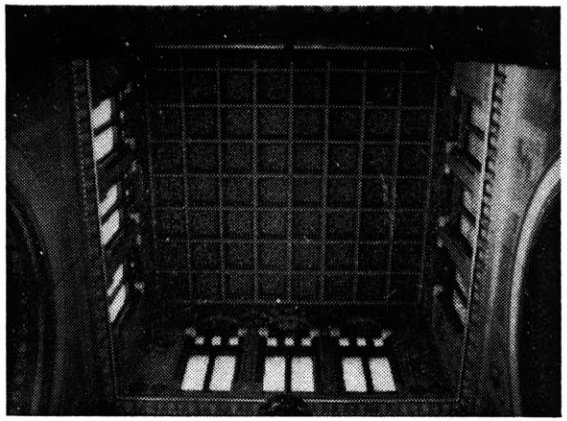


2-18 Interior decoration of the Church.

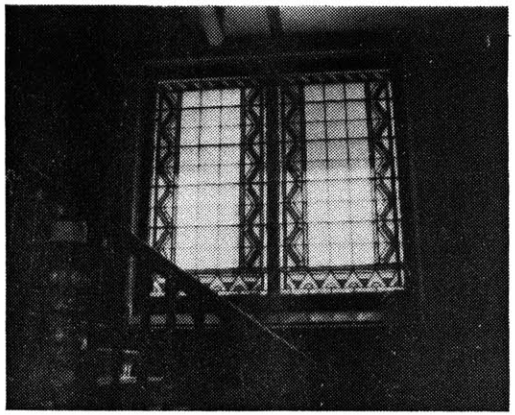
To carry out his schemes, Richardson contracted the services of John LaFarge who undertook responsibility to design and supervise the entire operation. Richardson noted LaFarge's enthusiasm and dedication as arising much less from any profit motive as from "a true artistic enthusiasm for a work so novel, and affording such an opportunity for the highest exercise of a painter's talents."[20] LaFarge was assisted by the American sculptor Augustus Saint-Gaudens as well as numerous other artisans and craftspersons. Carvings, mosaics, stained glass, murals, various fittings -- all have a sense of tradition infused with a lively and bold imagination. The main color scheme in the church is a soft brick red with blue-green tones, gold, and bits of blue. Painted murals and stenciling occur on every surface; gilded moldings and ceilings highlight architectural spaces and their surface textures; carved sandstone and marble ornament the apse behind the altar. Wood is also carefully used, black walnut for woodwork in the church and chapel, ash and oak in the vestibule, hewn beams (which are actually decorative casings concealing iron tie rods) span the vaults. One can get lost studying the intricacies of a single pattern in this infinitely detailed environment. The decorations are primarily abstract designs meant to recall early Christian motifs and clothe the walls, almost as if in a woven fabric. In contrast to these patterned surfaces, LaFarge's iconographic murals on the walls of the tower seem particularly realistic.



2-19 Floor tile in vestibule.



2-20 Upper reaches of the tower showing windows and ceiling.



2-21 Windows in stairwell of the vestibule.

The complexity of detail does not diminish even in the uppermost reaches of the tower -- instead it is this visual interest which helps draw the eye up into the dominant architectural feature of Richardson's design.

The stained glass windows now installed in the church are like a luminous continuation of this tapestry of surface decoration. It seems appropriate that the glass window openings admitting light into the structure should also be clothed in colored patterns and figures. The visitor feels completely enclosed within a very special place set apart from the rest of the world. Once in the church there are no connecting views to the outside secular world, not even hints of trees or buildings beyond.

Initially the windows were filled with common glass bordered by simple patterns of colored glass; it was hoped that they would all soon be replaced with memorial stained glass funded by different donors (as indeed they were). The tower windows by Samuel West are the only works done under Richardson's specific guidance. Originally glazed with panes of colorless glass, LaFarge supervised a new geometric pattern for these windows that interspersed smaller pieces of the colorless glass with reds and blues to tone down the elevated source of light. The relative brightness of the upper reaches of the tower still emphasize the uplift of this space but without destroying the softness and meditative quality of light at the level of the

parishioners. A Memorial Window Committee was established in 1875 to oversee the designing of windows in the main body of the Church:

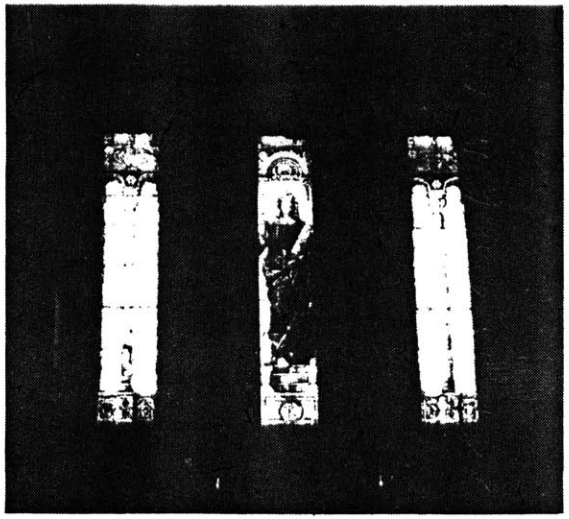
> ... much of the beauty of the interior will depend upon their judicious treatment ... their tint and tone should be in distinct harmony with its architectural character and mural decoration, bringing out in due relief the vaulting of the roof, so that wherever the eye turns it may rest with pleasure.[21]

The Committee was aware that plain glass would admit excessive light and glare and that at some seasons and hours of the day direct rays would even be painful to the eye and distracting to the contemplative mind. They also, however, wished to avoid a dim light in which it would be difficult to read. We can certainly agree that the high contrast of glaring fenestration would have strongly diminished the subtleties of this finely wrought interior. The Committee advocated designs representing scriptural subjects over abstract mosaic, feeling that their faith was founded on particular incidents of revelation of which they should be reminded.

The major windows were all completed between 1878 and 1888. Various artists, including LaFarge, William Morris, Sir Edward Burne-Jones, and several studios from England and France were commissioned for the pieces. Styles ranged from French painted glass with minimal leading to the pre-Raphaelite medieval style, from English domestic to LaFarge's glittering jewels. The seven

2-22 Window in west wall of north transept, LaFarge, 1884.

2-23 Windows in the apse, by Clayton and Bell of London, 1878.



2-24 Three lancet windows on west wall of the nave, John LaFarge, 1883.

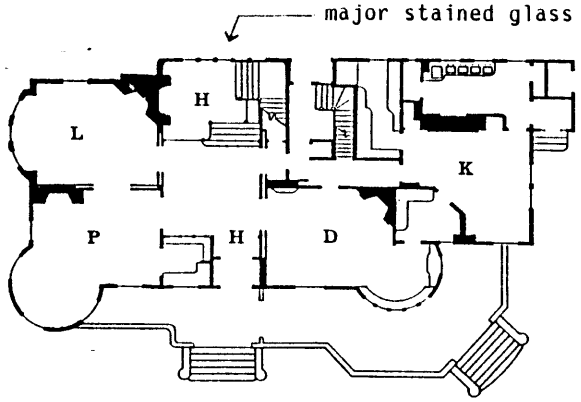
windows in the apse were completed first, followed by the large gallery windows in the south transept. The apse is the focus of attention for the service, and a relatively larger amount of clear and pale colors lets this space receive a higher degree of illumination than the seating areas of the congregation, i.e., the stage is lit. Patterned borders of deeper colors help make a gradual transition from opaque wall to light. These windows, in front of the audience, are the most finely detailed. The southern exposure of the building is most vulnerable to light penetration and thus received attention next. Both walls in the southern transept (south and west) were also completed in 1878, by various firms and with different donors. These windows are of much darker colors with a predominance of blue, lending a more subdued lighting and a greater feeling of enclosure to the seating areas. The light of the north transept seems to balance its mate as it is filtered through a quiet mossy green background. The effect is very peaceful. On the west wall of the nave John LaFarge's three slim panels of "Christ in the Act of Blessing" seem quite startling in their sparkly shimmer. Beaming down on the parishioner as he leaves the service, the background field of deep turquoise, iridescent nuggets subdues and disperses the light while it lifts the spirit with enthusiasm and hope. The most brilliant of all the windows, this effect is due to the many refracting surfaces of a multitude of glass jewels rather than the flat planes of typical sheet glass.

Yerxa-Field Residence

A classic illustration of stained glass in an 1880's residential setting can be studied at 37 Lancaster St. in the Avon Hill section of Cambridge. The house is an exemplary model of the matured Shingle Style as practiced by H.H. Richardson and others in the 1870's and 1880's and preferred by many affluent homeowners as they migrated to the outskirts of America's rapidly expanding cities. Avon Hill (bounded by Massachusetts Avenue, Linnaean and Raymond Streets, and Upland Road) is less than a mile from Harvard Square, but in 1830 there were only four houses in the entire area; by 1854 there were 81. Subdivision of original family farms into individual smaller plots continued until 1886 when the last of the Cooper-Frost farms on the southern slope of the hill was sold and Washington Avenue and Lancaster and Agassiz Streets were laid out for building. The area is typical of the first "suburbs" of burgeoning American cities. The homes had varying types and sizes of gardens, elegant carriage houses often adjoined the more palatial residences, and there was a horse-drawn trolley a short walk away on Massachusetts Avenue.[22]

The Yerxa-Field house, at 37 Lancaster Street, was built in 1888 by Hartwell and Richardson (William C. Richardson, not to be confused with H.H.), a local architectural firm which also built several other homes in the neighborhood. Shingle architecture, borrowed and adapted from the British usage of hung

2-25 Yerxa-Field residence, Hartwell and Richardson, 1888.



2-26 First floor plan.

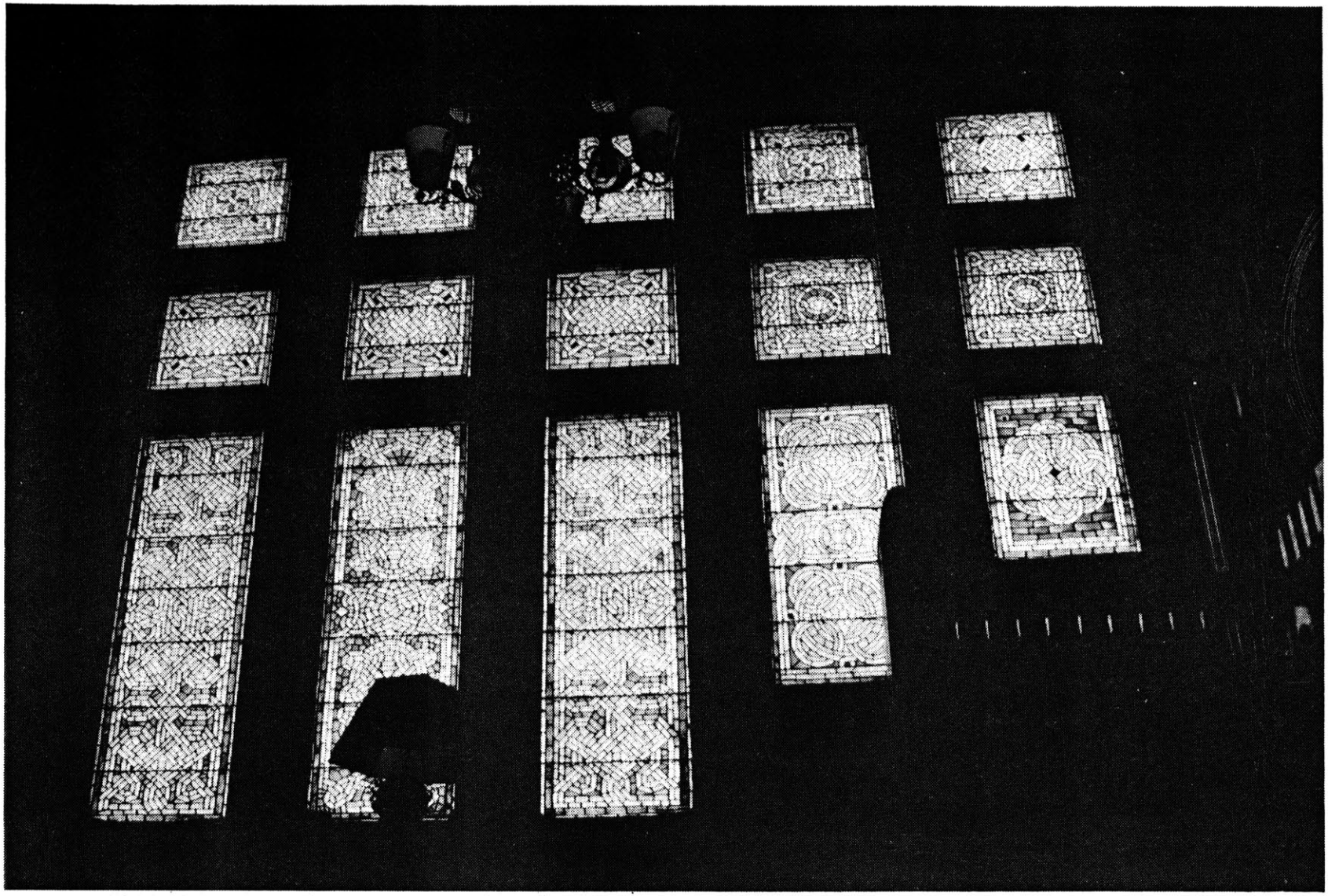
2-27 Section through entry, living hall, and major stained glass window.

tiles and slates, was at its zenith as an American expression of suburban informality combined with decorative ornamentation and picturesque flowing grace. The plans rejected the stiffness of classical symmetry and responded instead to interior space needs and the charm of irregular massing. Characteristic of the 1880's, the Yerxa-Field house has an open, flowing floor plan with wide double-size door openings and large, spacious rooms. Space tends to flow freely between smaller alcoves and the main rooms, and between the main rooms and the central stair hall. Gone are the constricting compartmentalized spaces of the more formal Victorian residences and in its place a precursor of the continuous flow of Wright's Prairie House plans. Fenestration is determined by the needs of the interior rather than a formal arrangement of the elevation.[23]

A critical feature of the Yerxa-Field house, and typical of the period, is a large central hall. Known as a "living hall" (and indeed, with a dimension of fifteen feet in width, the hall at 37 Lancaster Street is larger than many people's living rooms today), this space functioned as entrance, circulation center, stairway, and sitting room. The room was an important stylistic feature of the period and was so crucial that in more modest homes it was even provided for at the expense of spaciousness in the other common rooms on the first floor. A fireplace and seating area were a customary comfort in this communal receiving room of the family home.[24]

The commanding feature of the living hall in the house being studied is a two-storey window-wall of stained glass. Directly opposite the front entrance of the house, this sparkling window marks the very heart of the home with particular emphasis. It is situated in the north wall on the upper level of the two part living hall, five steps up from the first floor. From this central position it transmits a soft radiant glow over the hearth area of the landing as well as over the intersection of all the major pathways in the house. It strengthens the connection between the first and second floors by pulling one's gaze upward with its pattern of vertical brightness. From the gallery hall of the second floor it is a cheery welcome at any time of the day.

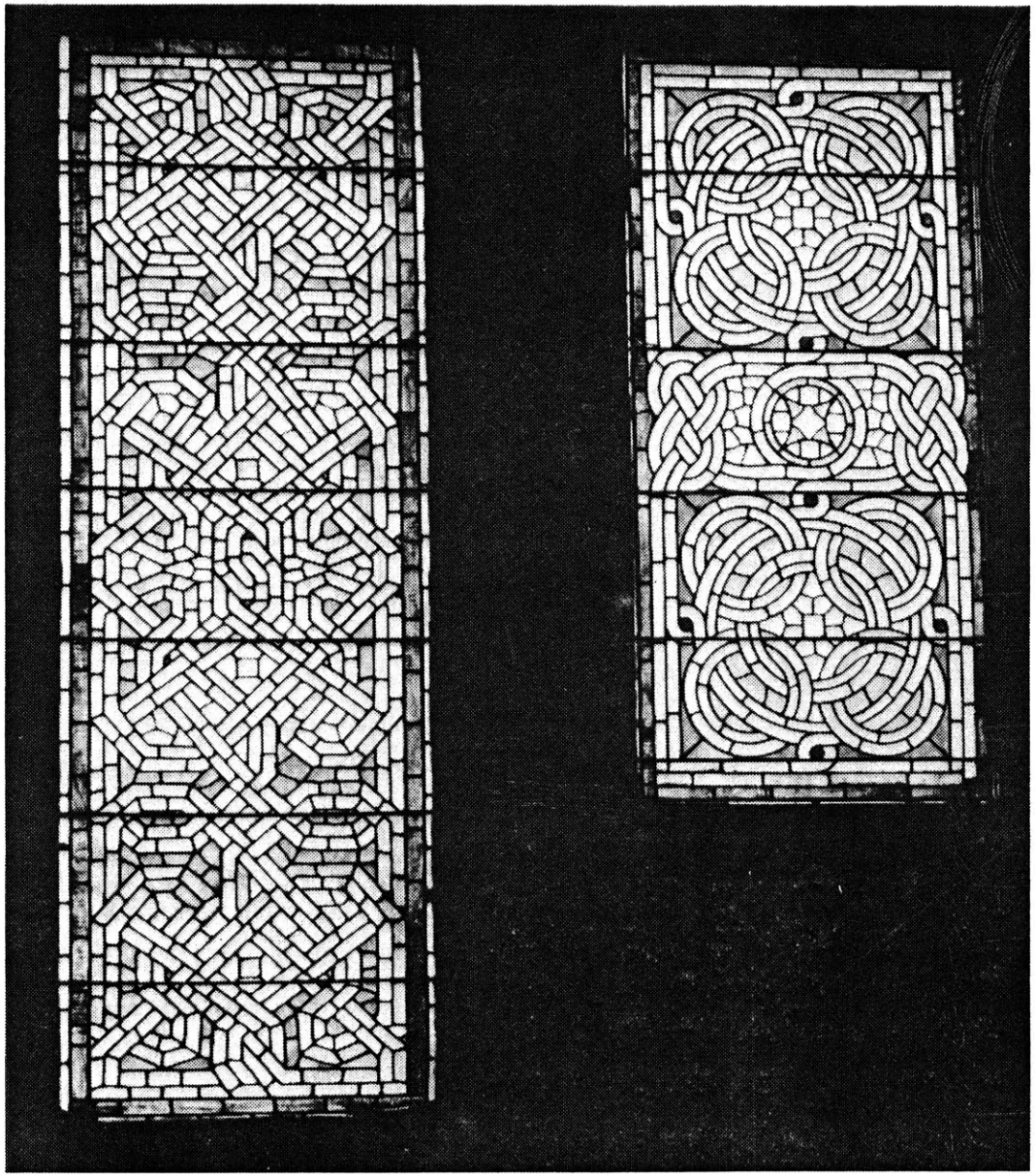
The "window" is actually fifteen separate panels organized in a rectilinear system of five bays, each with a long, vertical panel topped with two square panels. The whole is divided and supported in a framework of the same golden oak woodwork that continues around the house in paneling, molding, and finely carved bannisters and newel posts. No part of the window is made of transparent glass; view to the outside is nonexistent, and one's focus is kept entirely within the house. Considering the fact that the rear of the house was built only a few feet from the north lot line, one could assume that the beauty of the window and the other decorations of the house offered a better view than the siding of the neighbor's residence only twenty



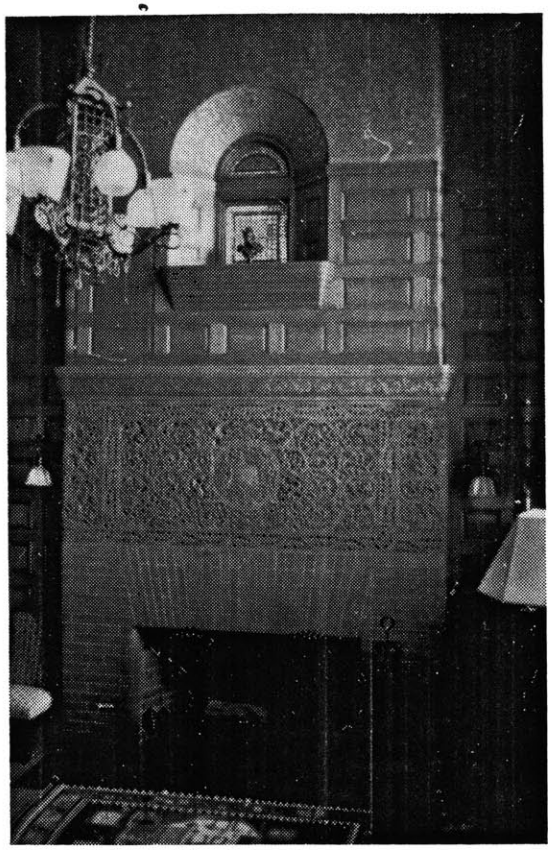
2-28 Two-storey stained glass window presiding over landing area of living hall.

feet away. In addition, privacy within the home was guaranteed both day and night whether the hall was lit by daylight or chandelier. Upon experiencing the hall myself, I found the lack of connection to the outside a little disconcerting. Given the open vistas from room to room and the generous clear windows in the other rooms on the first floor, I felt a bit constrained by not being able to orient myself on the north side as well. One has no idea whether there is a building or a wild forest or a parking lot on that side of the house. Incorporating a few small pieces of a clear colorless antique glass into the pattern could have afforded the small peek necessary to complete a link with the outside world while still maintaining privacy and the integrity of the design. Without even a fuzzy suggestion of the world beyond, one's attention is kept focused within the sheltering framework of house and hearth.

The colors in the windows are all muted quiet shades: pale gold, pale mossy green, light copper and camel, some heavily textured colorless pieces. A few small pieces of bright yellow and red lend accent and sparkle. Each window was designed as a panel in itself with a border design and a woven pattern that uses the heavier colors closer to the perimeter and progresses to the lightest and colorless pieces in the center. Thus, each panel appears as a square or rectangular medallion of sorts, taking its place in the overall grid pattern. This pattern of squares was also used in the wooden paneling of the hall and



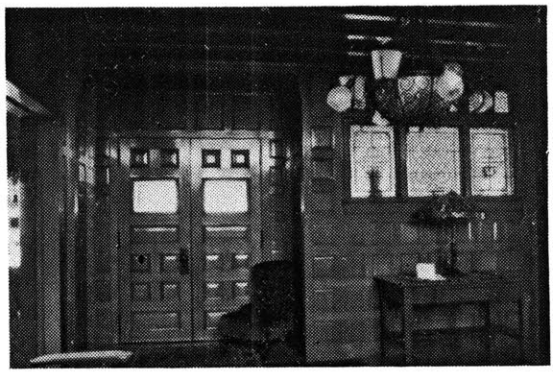
2-29 Panels of the window next to stairs.



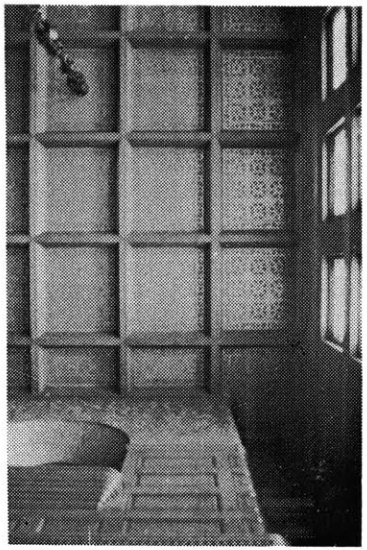
2-31 Fireplace with terra cotta; note small stained glass window in niche above.

2-30 Stairway and oak woodwork.

stairway and in the coffered ceiling above. The colors of the window continue rather than compete with the color scheme of its setting. The dominant coloring of the other materials in the hallway are browns and golds with small accents of muted red, blue, and green. The golden oak woodwork is everywhere with intricate turnings and carvings, the fireplace has a smooth brick facing with a hearth of tiny glazed, multi-colored tiles and an upper portion of finely wrought terra cotta. Two original wrought iron chandeliers are still in place and Oriental rugs of subdued reds and blues carpet the hardwood floor. The



2-32 Front entry with stained glass panels; note panels on right between hall and library nook.



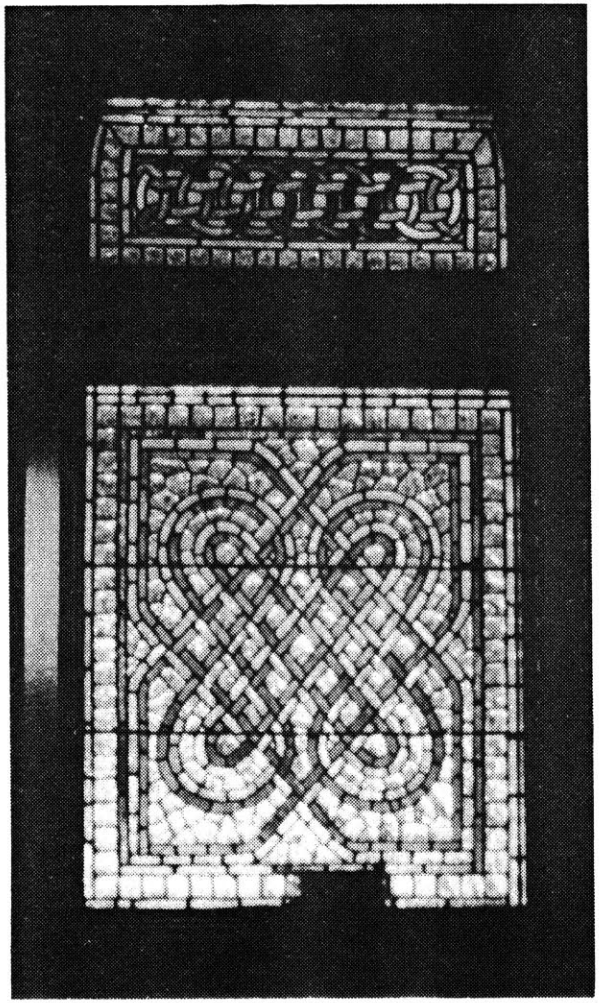
2-33 Coffered ceiling with stenciling.

colors of the stained glass window give a warm golden glow to this central focus of the home and add some stimulation to an otherwise rich but restrained environment.

We should ask ourselves what the effect might have been had these windows been glazed with ordinary clear panes. Obviously there would have been a much higher level of illumination, a brightness and whiteness revealing all in its path. Some of the coziness and protected feeling of this space would have been disrupted. Clear glazing to this extent would have been like a modern picture window, the outside view competing with the internal decor for attention. Fewer windows, perhaps a grouping of two or even three (this being the north elevation) of the typical double-hung variety would bring the lighting down to an appropriate level, but somehow would seem very pedestrian and almost crude in this otherwise elegant space. As in Trinity Church it seems appropriate that the detailing of surfaces continues across the glass just as strongly as it does with the other materials. The window is like a tapestry of light as much as the carpets are tapestries of dyed wool. It even echoes the abstract weaving design (popular at the time) of the hearth and the sinuous vine patterns in the fireplace terra cotta, the wallpaper, and the banister carvings.

There are several other smaller pieces of stained glass in the house as well, but their function seems to be more purely ornamental than illuminating. Between the south wall of the

living hall and the south wall of the house is a small library off the parlor. The wall separating library and living hall has two smaller panels (approximately 20" by 20") at eye level. They are composed in a similar weaving pattern, but the density of color is spread throughout and does not have the same centralized medallion effect as the major window. These windows do not receive nor transmit much light from either side and consequently are fairly lifeless. In addition to the same translucent gold tones of the other windows, these smaller panels have bands of opaque grey-blue, further enhancing their stone-like mosaic quality. There really is not enough light at any time of the day to take full advantage of these glass panels. In the serving area of the dining room above the built-in buffet is a bright piece of work, again purely ornamental with no view through to the outside. Being on an exterior wall it is well lit as the day progresses and adds a bit of luxury to the serving station. It continues the color theme of gold and neutral colors as well as the abstract weaving type of motif, although the patterns are by no means identical to those in the hall. Even in the servants' stairway to the third floor there are three small (less than a square foot) stained glass panels, again variations reminiscent of the major piece.



2-34 Interior panel between hall and library.

Modernist Movement

We can look at the architecture of the American Renaissance as the last blooming of the classical traditions, a last burst of profuse fruiting which quickly reached the point of overly ripened maturity and decayed under the weight of its own richness. Architects began to lament the misuse and oversaturation of classical motifs to the detriment of the more pure architectural issues of materials, structure, and aesthetics of form.[1] As early as 1892 Louis Sullivan in his Ornament in Architecture was suggesting:

> Ornament is mentally a luxury, not a necessary ... it would be greatly for our aesthetic good if we should refrain entirely from the use of ornament for a pèriod of years, in order that our thought might concentrate acutely upon the production of buildings well-formed and comely in the nude.[2]

The critic Russell Sturgis expressed similar sentiments in Architectural Record magazine in 1898:

> All recognized styles are more or less discredited by the sad misuse which they have undergone at the hands of our own generation and the preceding one.... It may be better if architects were allowed to build very plainly for a while.... If the architects were allowed to fall back upon their building, their construction, their handling of materials as their sole source of architectural effect, a new and valuable style might take form.[3]

In the same year a young Austrian architect Adolf Loos (b. 1870) in an attack on the currently popular Viennese Art Nouveau began trumpeting the crusading aspirations of a new generation:

> To make beauty in form instead of making it depend on ornament is the goal toward which humanity is aspiring.[4]

A decade later Loos' vehemence toward ornament had risen to an even more revolutionary fervor:

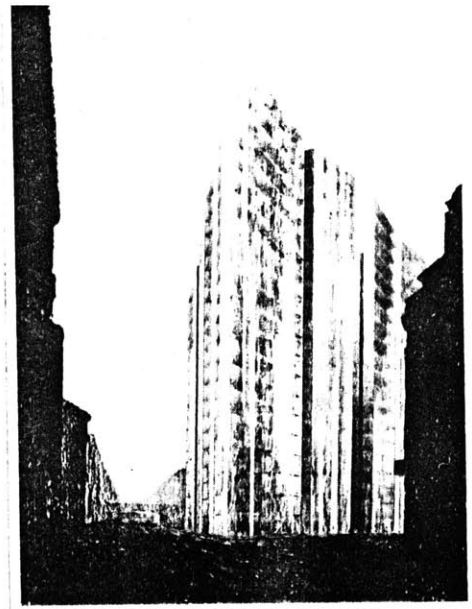
> Weep not. Behold the true greatness of our age, that it can no longer bring forth ornament. We have vanquished decoration and broken into an ornamentless world.... The evolution of culture is synonymous with the removal of ornament.[5]

This is strong stuff indeed. Loos was not just demanding a purification of ornament but postulated its extinction as a necessity for the advancement of our culture. It is in fact, he says, a sign of "greatness" to do away with ornament and deal strictly with essentials only. It is important to understand the forces which determined such an about-face in architectural thought.

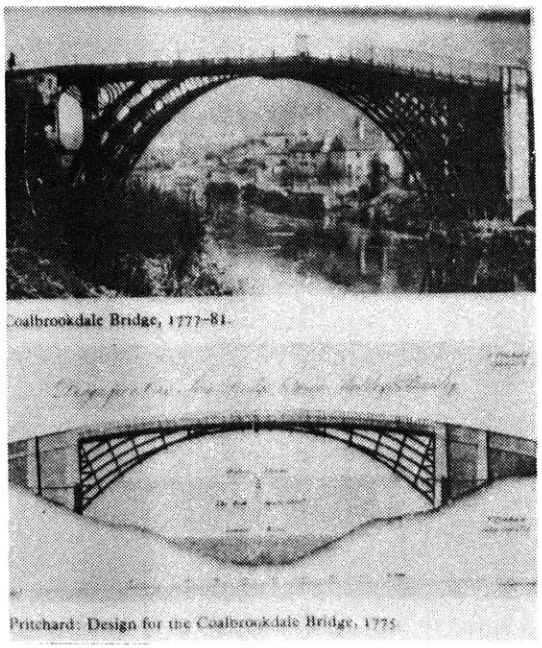
Nicholas Pevsner in his book Pioneers of Modern Design[6] has cited Adolf Loos along with Otto Wagner (b. 1841), Henri Van de Velde (b. 1863), Louis Sullivan (b. 1856), and Frank Lloyd Wright (b. 1869) as the first architects to admire the machine and understand its essential character and relation to architecture and the design of ornamentation. Whereas William Morris and his proponents in the Arts and Crafts Movement abhorred industrialization for its dehumanization of the worker and the decline in the quality of goods produced, these more forward-thinking architects began to foresee more positive results of

industrialization, such as new building materials and building processes. Specifically, three new building materials, steel, reinforced concrete, and plate glass, offered previously unthought-of opportunities in form making. In addition, the processes of mass production allowed standardization and prefabrication of pieces that could speed up construction and contribute to a consistency of quality. Set against these technological opportunities was a need for the invention of new building types to provide for the lifestyles of an increasingly urban and mobile population. "The job of today is not to build cathedrals but big hotels, railway stations, arterial roads, market halls, towers on grid plans in replacement of slums."[7] The combination of different problems to be addressed and new potentials to be explored spurred new directions in building and the language of form and space-making. In explaining the tenets of the "New Architecture" Walter Gropius wrote:

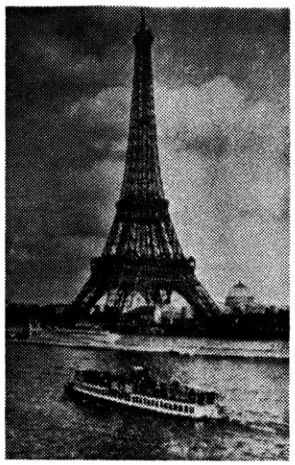
> During the course of the last two or three generations architecture degenerated into a florid aestheticism, as weak as it was sentimental, in which the art of building became synonymous with meticulous concealment of the verities of structure under a welter of heterogeneous ornament. Bemused with academic conventions, architects lost touch with the rapid progress of technical developments and let the planning of our towns escape them.... A modern building ... must be true to itself, logically transparent and virginal of lies or trivialities, as befits a direct affirmation of our contemporary world of mechanization and rapid transit. The increasingly daring lightness of modern constructional methods has banished



3-1 Friedrichstrasse skyscraper project, Ludwig Mies van der Rohe, 1921.



3-2 Early iron bridges



3-3 Eiffel Tower, Paris, 1889.

> the crushing sense of ponderosity inseparable from the solid walls and massive foundations of masonry.[8]

The next section of this thesis will summarize those aspects of the larger context of the modernist movement in architecture which form the backdrop against which any thoughts on stained glass of the period must be considered.

Iron, and later steel, was the new material with the most serious implications for building. Originally fabricated in the early 1800's, cast iron and then wrought iron were used as structural members but were not yet regarded as worthy of aesthetic consideration. Instead they were hidden inside other more acceptable materials. Eventually higher strength steel was developed and tensioned reinforcing rods were used in concrete to increase its performance also. It was the engineers who first disclosed the inherent beauty of all steel construction in the graceful and elegant suspension bridges of the mid and later nineteenth century.[9] Eventually structures such as the Eiffel Tower (1889) and Paxton's Crystal Palace paved the way for the first skyscrapers by replacing load-bearing walls with a thin steel skeleton. The resultant grid of steel cells, so different from the solid planes of bearing walls, required a new vocabulary of expression.

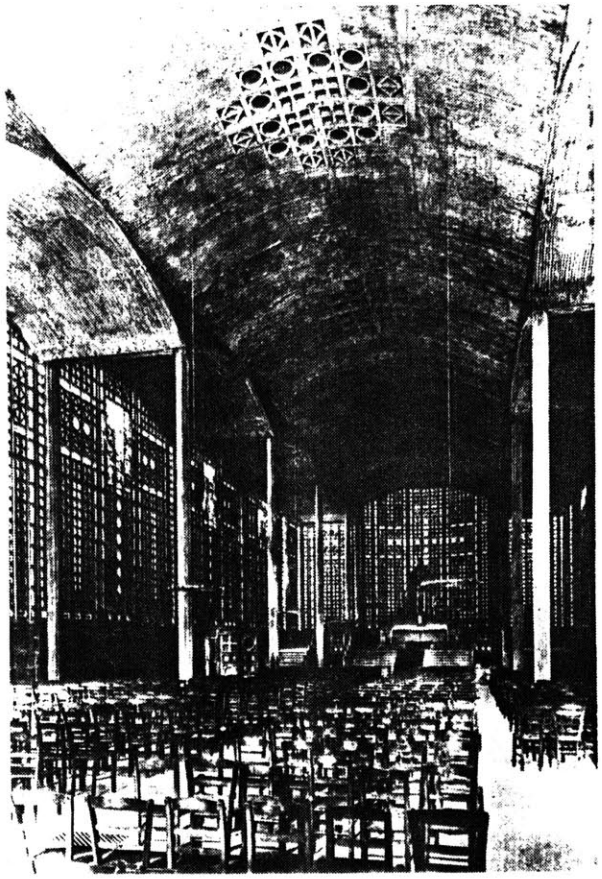
In 1870 William E. Ward and Thaddeus Hyatt began studies to analyze and calculate the properties of concrete and iron used in combination. Their work led to the introduction of steel

reinforced concrete which added tensile strength to the compression qualities of concrete. The results was the shrinking of bearing walls to compact piers and the possibility of great structural slabs for both horizontal and vertical planes. Auguste Perret and Tony Garnier are generally credited with being the first to use concrete inside and outside without any effort to conceal it or adapt it to the spirit of past styles.[10]

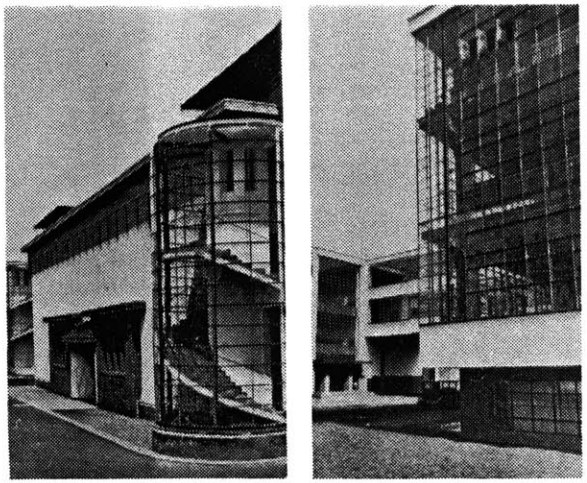
The result of the comparatively thin framework systems available in steel or concrete was a savings in bulk, space, weight, and money. Essential structure could now be wide-spanned and completely open. Old notions of space, weight, and support had to be re-examined. Instead of bearing systems walls could now be secondary infill systems, lightweight and variable. Windows, once holes wrested from the thickness of a bearing wall, could now be much more variable, even completely continuous if so desired. Glass once limited by the structural requirements of a wall took on new meaning as a more comprehensive wall material and enclosure membrane. Gropius maintained:

> As a direct result of the growing preponderance of voids over solids, glass is assuming an even greater structural importance. Its sparkling insubstantiality, and the way it seems to float between wall and wall imponderably as the air, adds a note of gaiety to our modern homes.[11]

The early Modernists were fascinated with the properties of glass which they were now free to explore and develop to the fullest. With the load-bearing elements kept within a struc-

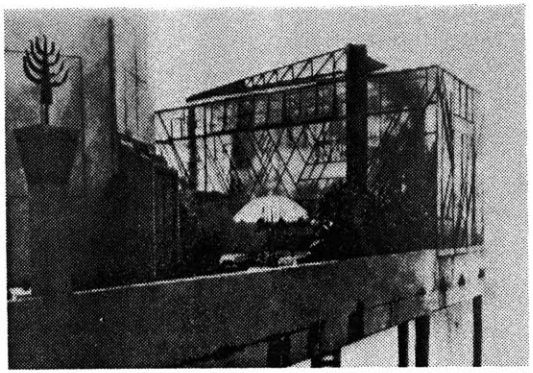


3-4 Church of St. Theresa, France, Auguste Perret, 1925.



3-5 Brick front and glassed stairwell, Werkbund Exhibition Administration Building, Cologne, Gropius and Meyer, 1914.

3-6 Glass curtain wall corner, Bauhaus building, Dessau, 1925.



3-7 Glass House over the Seine, International Exposition of Decorative Arts, Paris, Peter Behrens, 1925.

tural core it was possible for the outside wall to become a glass wrapping allowing light to penetrate deeply. Glass could render an outside wall relatively non-existent in a visual sense, seen only when reflections or distortions occurred. A glass wall could function as a weather and noise membrane leaving the structural system and spaces within in complete view. In his Glass in Modern Architecture, published in 1929, the German architect Arthur Korn stated:

> Glass is an altogether exceptional material, at once reality and illusion, substance and shadow; it is there yet it is not there.... glass is noticeable yet not quite visible. It is the great membrane, full of mystery, delicate yet tough. It can enclose and open up spaces in more than one direction. Its peculiar advantage is in the diversity of the impression it creates.[12]

It is indicative of the period that Korn's picture book shows almost exclusively large expanses of clear plate glass and gives no reference to color or texture whatsoever. He considered transparency to be glass' primary property over color and brilliance.

The prefabrication of parts and systems was a radical departure from the traditional modes of hand-crafted building. The Crystal Palace was one of the first examples of such a system; never had a building of such enormous size been erected in only a few months. Architects saw the possibilities for construction at a fixed price and of consistent quality. It was

an economic fact of the age that factories could produce goods faster and cheaper than an individual workman. Walter Gropius understood and encouraged the potential of machinery to ease the burdens of life.

> The elementary impulse of all national economy proceeds from the desire to meet the needs of the community at less cost and effort by the improvement of its productive organizations. This has led progressively to mechanization, specialized division of labor, and rationalization ... which have the same implications for building as for every other branch of organized production.[13]

He stressed that mechanization was not an end in itself but could have only one legitimate objective:

> To abolish the individual's physical toil of providing himself with the necessities of existence in order that hand and brain may be set free for some higher order of activity.[14]

He also affirmed the standardization of architectural components and the ensuing homogeneous character of towns as the "distinguishing mark of a superior urban culture." Gropius knew that mechanized industry was the inevitable method of the future. At the Bauhaus manual crafts were learned not as ends in themselves but to provide all-round training between hand and eye and as a practical first step in enabling a student to better understand and improve industrial processes.

The diversity of new materials and methods along with the rejection of out-moded classical styles made possible a new

attitude in building, that of functionalism. Rather than creating aesthetic masterpieces based on historical prototypes the new architects wished to explore and satisfy the changed physical needs and functions of twentieth century urban men and women. The design of buildings was to be based on program needs, site conditions, and the inherent nature of the construction materials used. Form was no longer to be based on adaptation of certain symbolic precedents but instead should develop from the problem itself. The result would be a building with the efficiency and satisfying beauty of a well-oiled machine.[15]

I have tried to summarize in just a few pages some of the most stimulating and demanding issues confronting concerned architects as they entered the twentieth century. It is important to appreciate the breadth and newness of their concerns prior to any investigation of their attitudes toward such a traditional material as stained glass. In a sense the most visionary and original thinkers seemed willing to reject and overthrow completely all that had previously transpired in the name of architecture. It would be helpful to look more closely at the assumptions and implications of this rational objectivist approach.

In an article entitled "Meaning in Architecture" Christian Norberg-Schulz considers functionalist architecture to be a typical expression of a "post-medieval" world.[16] In the Medieval world reality was understood as an ordered cosmos where

every human product and action got its meaning in relation to this order. Man (and everything else) gained his (its) significance by belonging to a level in a hierarchical and differentiated world. Man has protested this mystical totalitarian understanding and has gradually accumulated the empirical experiences to free himself and face the world "as it is." The rapid advancement of scientific understanding "finally seemed to give the wish for a rationalistic conception of the world a firm basis and modern building technique made a correspondingly functional architecture possible.... Its clarity and contact with practical reality could not be rejected."[17] In Pioneers of Modern Design (1936) Pevsner concurs:

> [While] thirteenth century walls were made translucent to carry the transcendental magic of Saintly figures rendered in coloured glass, the glass walls are now clear and without mystery, the steel frame is hard, and its expression discourages other-worldly speculation. It is the creative energy of this world in which we live and work and which we want to master, a world of science and technology, of speed and danger, of hard struggles and no personal security, that is glorified....[18]

Norberg-Schulz questions whether this rational world conception is satisfactory and points out that it has been challenged in many fields, from literature to psychology.

He reminds us that everyday perception functions in a fundamentally different way than scientific analysis. Science tries to give objective descriptions of objects and laws ordered

in logical systems. In our daily experience we synthesize complex wholes whose components are not necessarily logically related. Art performs the function not of describing but of giving direct expressions of certain aspects of reality. In this sense it concretizes the phenomenal complexes of life such as values and individual situations. The sterility of much functionalist architecture is devoid of this concretization of everyday human values and concerns.

Contemporary architect and stained glass artist Kenneth von Roenn, Jr. has addressed himself to the question of what ornament is.[19] He finds that the nineteenth century notion equated ornament with decoration and lost the sense of its symbolic meaning. In previous eras ornament denoted rank-orders of significance between different kinds of buildings. The type, extent, and richness of ornamental program had an ethical and orienting function that helped man to locate himself in his social environment. Von Roenn further distinguishes between ornament and architectural art:

> Ornament is primarily concerned with broad visual assertions that spark recognition in the viewer; the level of perception is not intended to go beyond recognition of the image and its symbolic representation. Architectural art ... stimulates the viewer beyond the level of recognition and acceptance, to that of perception, contemplation, and resolution. Architectural art goes beyond ornamental art in engaging the viewer intellectually and visually.... Architectural and ornamental art, however, because they are public, must address the concerns of humanity that are

> of relevance to the architecture of which the art is a part.[20]

In an attempt to re-establish the ethical function of architecture in society the modern functionalists mistakenly anticipated a universal society of shared values beyond traditional cultural confines. However, as we approach the end of the twentieth century life is still full of complexity, ambiguity, and tensions and our built environment must symbolize and rhetorically express our reality (cultural and individual) in order to have meaning to us.

> Ornament both presupposes and serves to strengthen a way of life that integrates rather than separates spirit and body, work and leisure, individual and society.... In its abstractness [modern architecture] could not communicate those qualities we now recognize as essential to a humanistic possession of architectural environments.[21]

As a rhetorical device ornament (or more precisely the artist) must discover the appropriate social and architectural concerns of our age and engage us in varying levels of dialogue "from polite small talk, to spontaneous discussion to proclamations." Von Roenn proposes for stained glass a role just short of architectural art. It is, he feels, the responsibility of each individual artist to determine what that necessary dialogue is today and to express it in a contemporary language.

The emphasis on anonymous neutral functionalism in the end left many modernist buildings not very functional at all, in a

fuller sense, for each individual inhabitant. It does no good to satisfy the physical needs of a person if their spiritual appetite is left undernourished and misdirected. Both critics point to a more poetic and symbolically defined built environment as necessary to restore an individual's fullest relationship to his/her own personal world. In defining the place of art in architecture von Roenn asserts that there should be latitude in the built environment for an individual to formulate his own personal interpretations of meaning.

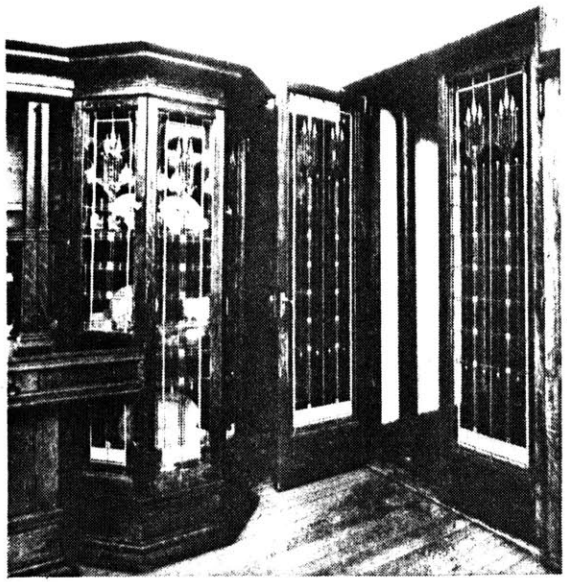
Modernist Architects

As I searched for commentary on stained glass and how it was affected by the growing modernist movement it became clear that the most telling fact was the dearth of information to be found. Except for a continuation of historical styles in traditional church architecture, where its chief advocate and concerned critic was the architect Ralph Adams Cram, a Gothic revivalist, the material seems to have dwindled slowly but steadily in popularity. In their search for purism, efficiency, and expression of twentieth century concerns the modernists relegated stained glass once again to the confines of religious symbolism.

In the early stages of his career Frank Lloyd Wright incorporated some of the emerging attitudes into a new approach with stained glass. Wright treated colored glass as glass, not as a

step-child to painting, and designed patterns with mechanical production means in mind. Unfortunately his use of the material as a light screen was not developed and carried on outside the Prairie Style community of architects. The proponents of the Art Nouveau style in art and architecture brought only a change of style to the traditional art glass window, not any true innovations. Bruno Taut expressed a visionary view of entire buildings of colored glass which would transform the misery and confusion of war-torn Germany into a spiritual existence. Taut's mystical imagination invented a number of ways for colored glass to be exploited by lighting and new methods of manufacture.

As the Modernist movement matured in influence the Bauhaus included stained glass as one of its craft workshops. Even here, however, its potentials as light modulator and window-wall were obscured by a painterly approach. I found no mention of any colored glass in the work of Ludwig Mies van der Rohe and the first example by Le Corbusier is not until 1950 in the Chapel at Ronchamp. In this building Corbu rejects traditional stained glass windows but does devise his own system of concrete and colored glass screen wall which recall a simplified primitive sense of sacred space.



3-8 Dining room of Warren MacArthur House with art glass designed by Wright representing blossoms and stems, 1902.

Frank Lloyd Wright

Prior to the strongest expressions of International style purism Frank Lloyd Wright (1869-1959) began advancing architectural uses of stained glass windows which clearly broke with traditional conventions. As an apprentice in Louis Sullivan's office, he shared his mentor's view that ornament played an essential role in architecture, one which had been misplaced and confused in the recent profusions of eclectic classicism. Wright recognized much recent ornament as mere decoration, or "appliqué," and offered this definition:

> Ornament: Integral element of architecture, ornament is to architecture what efflorescence of a tree or plant is to its structure. Of the thing, not on it. Emotional in its nature, ornament is -- if well conceived -- not only the poetry, but is the character of structure revealed and enhanced. If not well conceived, architecture is destroyed by ornament.[22]

Wright's art glass, which appeared primarily in his Prairie Houses between 1893 and the 1920's, reinforced the geometrical basis of his plans and the open flow of his spaces. Their motifs strengthened his interior themes by continuing them across the window planes.

> In the openings of my buildings, the glass plays the effect the jewel plays in the category of materials. The element of pattern is made more cheaply and beautifully effective when introduced into the glass of the windows than in the use of any other medium that architecture has to offer. The metal divisions become a metal screen of

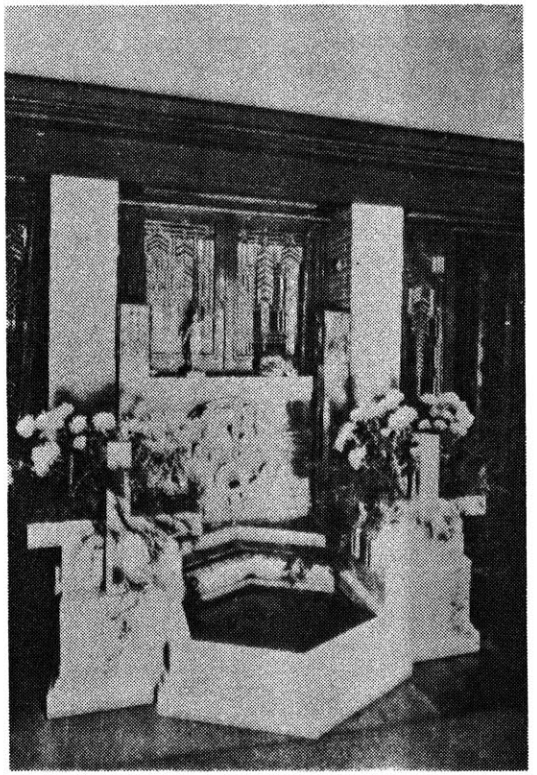
> any pattern -- heavy or light, plated in any metal, even gold or silver -- the glass a subordinate rhythmical accent of any emotional significance whatever, or vice versa. The pattern may be calculated with reference to the scale of the interior and the scheme of decoration given by, or kept by, the motif of the glass pattern.[23]

He believed that ornament should be designed "with a thorough knowledge of what today's machinery can do most efficiently and well."[24] Glass is easier to cut in straight lines than curves, particularly if by machine, and this prompted Wright's use of rectangles, diamonds, and triangles almost exclusively. In 1908 he explained:

> The windows usually are provided with characteristic straight line patterns absolutely in the flat and usually severe. The nature of the glass is taken into account in these designs as is also the metal bar used in their construction, and most of them are treated as metal "grilles" with glass inserted, forming a simple rhythmic arrangement of straight lines and squares as cunning as possible as long as the result is quiet. The aim is that the designs shall make the best of the technical contrivances that produced them.[25]

Wright's earliest designs were often stylized forms of a plant found on the site. With time his designs became more pure abstract geometrical patterns.

Concern for the expression of the true nature of a material led Wright to employ glass as a pure and transparent membrane, an attitude in direct opposition to most of the popular recent work by artists such as Tiffany and La Farge. His conventional-



3-9 Dana House, 1902.

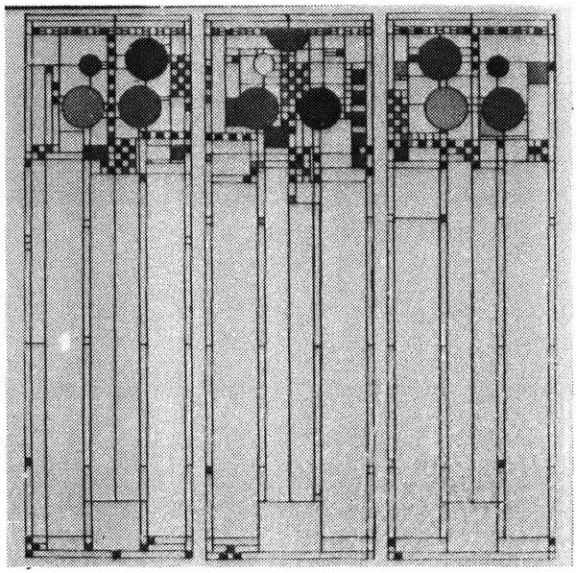
ized plant forms were meant to enhance and complement the view to the natural outside world, not to obstruct it.

> Nothing is more annoying to me than any tendency toward realism of form in window-glass, to get mixed up with the view outside. A window pattern should stay severely "put." The magnificent window painting and plating of the windows of the religious edifice is quite another matter. There the window becomes primarily a gorgeous painting--painting with light itself.[26]

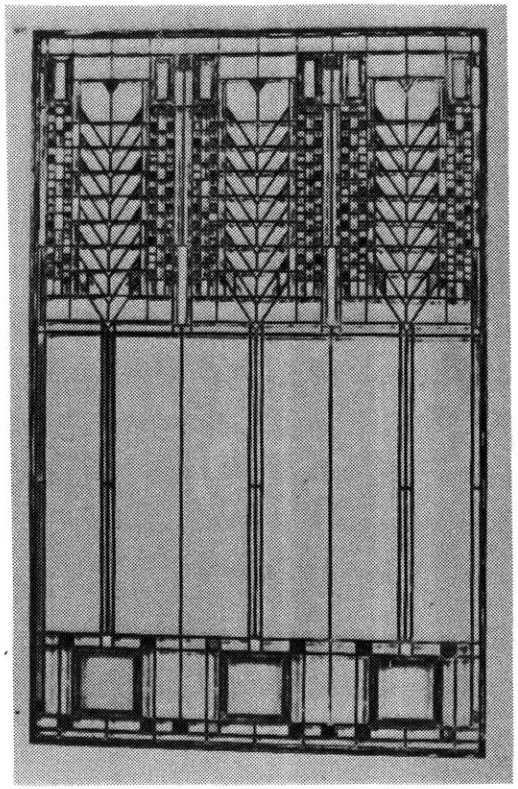
Wright approached stained glass with the objectives of an architect, not those of an easel painter. For him art glass panels whether interior or exterior were "light screens" which could afford a sense of enclosure without interrupting sightlines. The leaded casement windows of the Shingle Style houses of the 1870's and 1880's, which Wright admired, no doubt had a direct bearing on his attitude.[27] A student of Wright's, the architect Edgar Tafel, later wrote:

> Wright as a designer of "open" plans for houses, needed something to "soften" his expanses of glass. He was not, however, treating one element with another by covering up glass with draperies. Rather, he was treating glass as glass consistent with his basic philosophy of the nature of materials.[28]

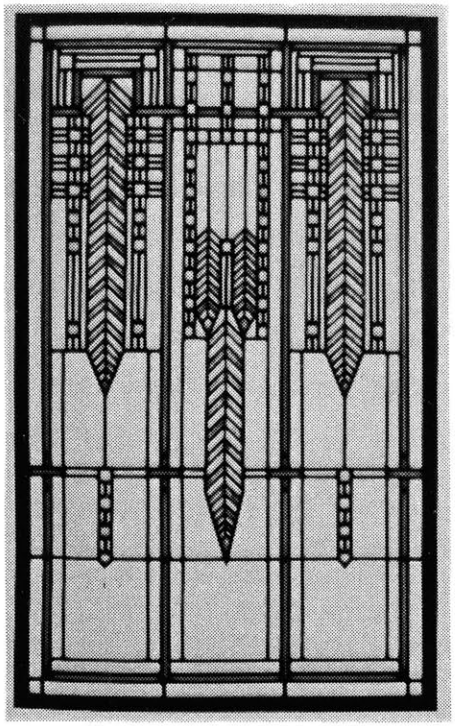
It is curious that Wright's advances in a truly architectural use of stained glass did not receive further attention and development. His use of the material as an architectural medium of integrated ornament, transparency and light modulation, and graphic composition was not taken up by other glass designers



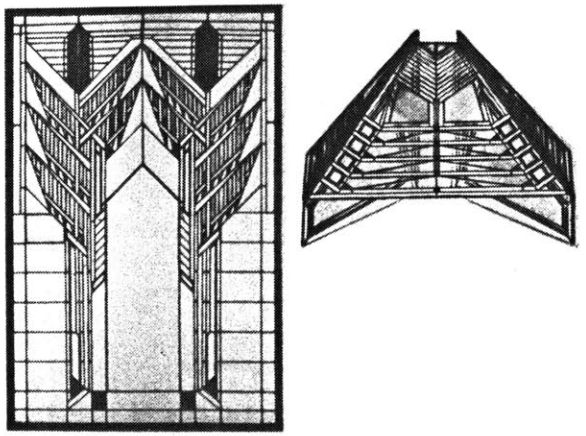
3-10 Avery Coonley playhouse, 1912.



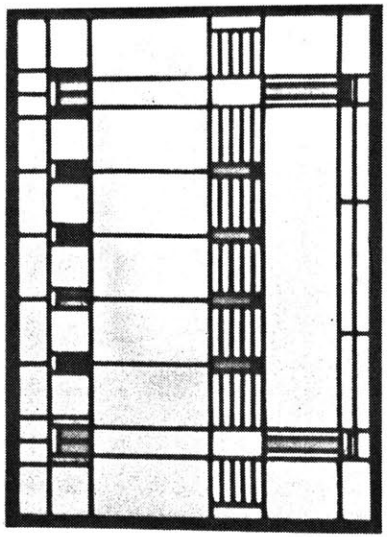
3-11 Window for the Darwin D. Martin House in Buffalo, 1904, showing stylized wheat plants.



3-12 Window design of weeping willows by Arthur Heun, 1902, very similar to Wright's work.

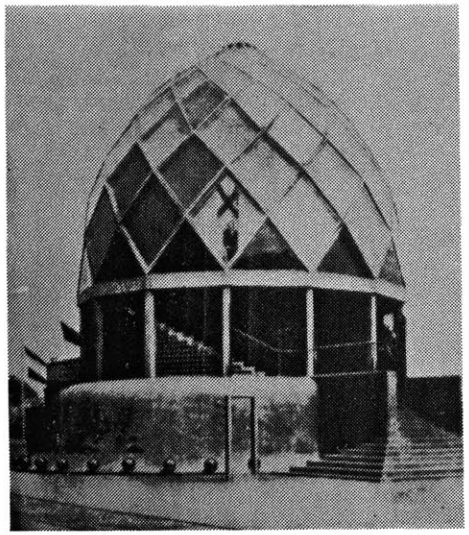


3-13 Window and lampshade carrying sumac motif, Dana House, 1902.



3-14 Ward Willits house, 1902.

until after World War II. It is possible that the influence of the popular Tiffany style was just too pervasive. Or perhaps America was not yet a strong enough international architectural influence to effect drastic changes in such a traditional material.[29]



3-15 Glass House by Bruno Taut, Werkbund Exhibition, Cologne, 1914.

3-16 Interior of Glass House.

Bruno Taut

In 1914 Bruno Taut (1880-1938) built his famous Glass House at the Werkbund Exhibition in Cologne. Sponsored by the local German glass industry to advertise the many aesthetic ways that the new material could be employed, Taut's building was an experiment in possibilities of expression rather than a statement of the emerging functionalist architecture which was soon to follow. Taut's objective was "the enclosure of space by means of glass" and he employed colored, opaque, and clear glass to create various effects of distance, silhouette and nearness.[30] Immediately inside the building, curving stairways led visitors past prismatic walls of glass block up to a shimmering cupola room and then back down to a circular interior space:

> The circular space was enclosed by a wall of translucent silvered glass set between larger stained glass panels created by several Expressionist painters, including Max Pechstein.... the real centerpiece of this room was a sparkling fountain which was surrounded by a glass mosaic floor in a white, blue, and black pattern. Red case glass and gilded glass tiles covered a conical ceiling leading up to a circular opening directly above the pool of water. The light admitted through this oculus from the brighter cupola room above produced a flickering, disorienting impression as it was reflected by the fountain and the glazed surfaces. From the fountain room a water cascade flanked by two stairs led to the semidarkness of the basement. The walls enclosing the cascade stairwell were covered with polychrome glass mosaics. This display of sound, light, and colour was further enhanced by long chains of glass pearls placed in the water and lit dramatically from below by lights situated under the water

> basins of the cascade. At the lower level a dark tunnel, lined in soft purple velvet led to a cave-like, completely dark "kaleidoscope room" in which abstract patterns of coloured light were projected onto an opaque screen.[31]

As a leader in the utopian German Expressionist movement Taut authored a number of fantastic projects, mostly unbuilt, with such captivating titles as "Crystal House in the Mountains," "The Matterhorn Studded with Crystalline Ornaments," "Illuminated Glass Architecture Floodlit at Night by Colored Glass Beacons," and "House of Heaven."

> Taut's work stood for a people's utopian expectations for a new society after the German Revolution of 1918. The emphasis was on transformation, metamorphosis, and transcendence.[32]

Much of Taut's inspiration came from Paul Scheerbart, a visionary poet with a fanatical and idealistic love for glass architecture. Scheerbart's often prophetic book Glasarchitektur inspired a generation of young German architects with his notions of liberation from brick boxes into the clear colorful light of the future. Taut requested that Scheerbart compose fourteen mottoes of the future to be incised into the concrete beams of his Werkbund Exhibition Pavilion.

In his theoretical project the "House of Heaven" Taut described his vision of the cathedral of the future:

> Between the inner and outer glass skins is the lighting. It will be switched in and out, changing from lighting the

1 Happiness without glass
How crass!

2 Bricks may crumble
Coloured glass endures

3 Coloured glass
Destroys hatred

4 Coloured happiness
Only comes in a glass culture

5 Without a glass palace
Life becomes a burden

6 A glass house does not catch fire
There is no need for a fire brigade[5]

7 Parasites are not nice
They will never get into the glass house

8 Combustible materials
Are a scandal

9 Greater than the diamond
Is the double walled glass house

10 Light permeated the Universe
It comes to life in the crystal

11 The prism is marvellous
That is why the glass house is great!

12 By shunning colour
One sees nothing of the Universe

13 Glass makes everything light
So use it on the site

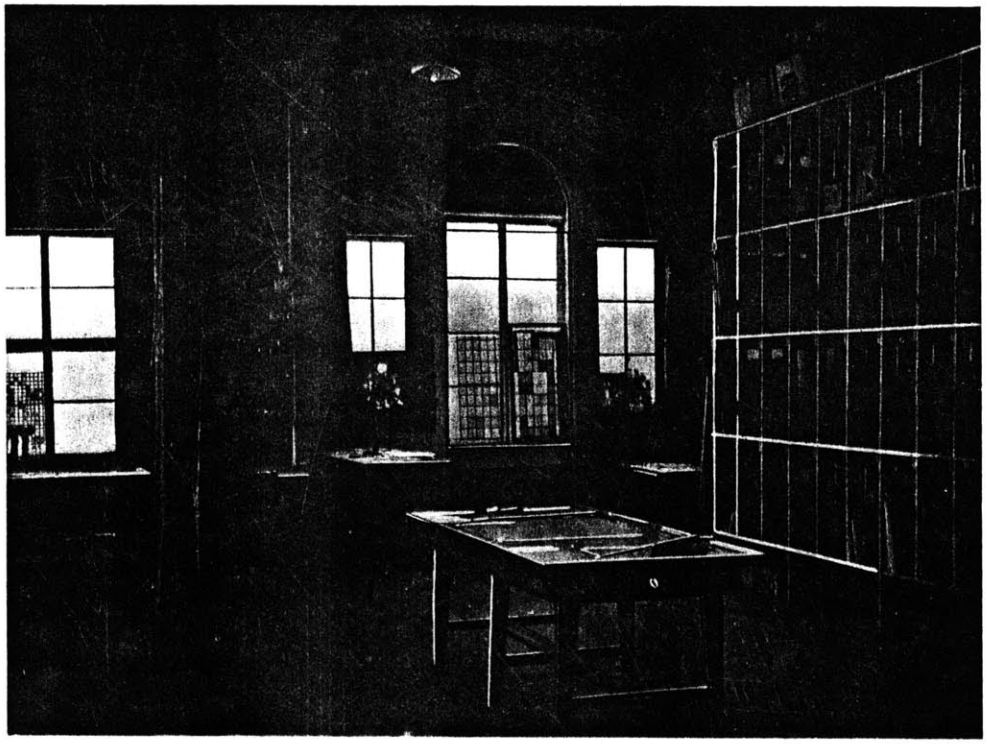
14 Glass opens up a new age
Brick building only does harm.

3-17 Inscribed mottoes for the Glass House, by Paul Scheerbart.

3-18 Crystal House in the Mountains, 1920.

> proceedings in the room, to creating an effect outside. Both inside and outside will be lit through richly coloured glass walls. If one approaches by night from the air, it appears from far off like a star. And it sounds like a bell.
>
> To build the roofs, prisms of coloured glass will be electrolytically joined, and for the walls, the prisms will be poured. In a very stable structure the glass prisms of the roof could also be poured as one. Roofs and walls will echo the crystals of the outer structure in a subdued manner, like bas-reliefs, crisp and stylish, and in their glittering richness they will absorb the deepest colours of the sparkling glass windows. In fact they are not glass "windows," since walls and roof are all bright and colourful.[33]

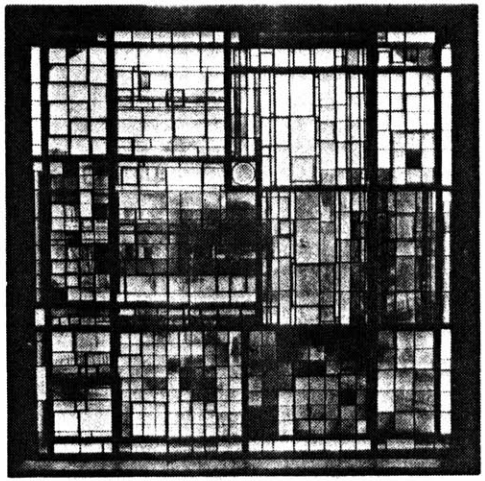
Although obviously a futuristic extravaganza in its entirety Taut foresaw the possibility of entire walls (and roofs) of glass, colored as well as plain. The structural capabilities of steel and concrete frames allowed him to envision the possibility of entire window-walls of colored glass, thus doing away with the distinction of window as a hole in the wall.



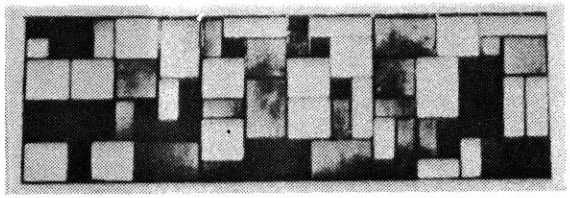
3-19 Stained glass workshop, Bauhaus Weimar, 1923.

The Bauhaus

Aside from Wright's work and the visionary Expressionist enthusiasm for colored "crystal," stained glass received little attention or new direction from the leaders of the modernist movement. As a craft it was incorporated in the Bauhaus course of education while Walter Gropius headed the school.[34] While most American architectural schools still labored under the after effects of eclecticism the Bauhaus was founded not to promote a particular dogma or style but to exert a revitalizing



3-20 Window in the hall of the house of Dr. Otte in Berlin by Josef Albers, about 1923.



3-21 "Compositions of Glass Fragments," Josef Albers, 1921.

influence on design in general. Its founders wished to foster the intrinsic creative design faculties of each student rather than supply the rules and patterns of the past in the manner of the traditional Ecole des Beaux Arts. The educational program was devised to remove the barriers separating architecture, applied art, and technology.

Both manual and intellectual training were considered necessary to this effort. Each student was required to register for a formal three-year apprenticeship with a local trade, the objective being to improve eye-hand coordination and judgment and to provide a basis for understanding more complex industrial methods later in the student's career. Workshop instruction was given in stone, wood, metal, clay, glass, pigments, and textile looms. The intellectual training consisted of formal instruction in Aspect (the study of nature and materials), Representation (plane geometry, construction, drafting, and model-making), and Design (volumes, colors, and composition). Gropius wrote:

> Our ultimate goal, therefore, was the composite but inseparable work of art, the great building, in which the old dividing-line between monumental and decorative elements would have disappeared forever.
>
> The quality of a man's creative work depends on a proper balance of his faculties. It is not enough to train one or the other of these, since all alike need to be developed. That is why manual and mental instruction in design were given simultaneously.[35]

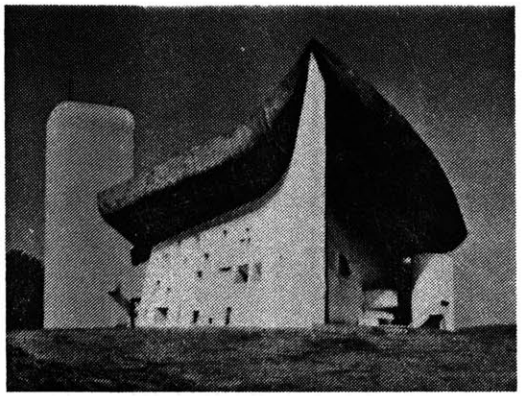
Initially headed by Johannes Itten and then Paul Klee the stained glass workshop was soon given over in 1923 to Josef Albers, at the time a gifted and promising Bauhaus student. Albers was better able to combine the Bauhaus ideals of artistic sensitivity and craftmanship but the workshop still suffered from a lack of important commissions to sustain it. According to Hans Wingler's documentation in The Bauhaus,

> Aside from small pictures, comparatively little was produced. The sacred character of glass staining limited its application within the framework of architecture.[36]

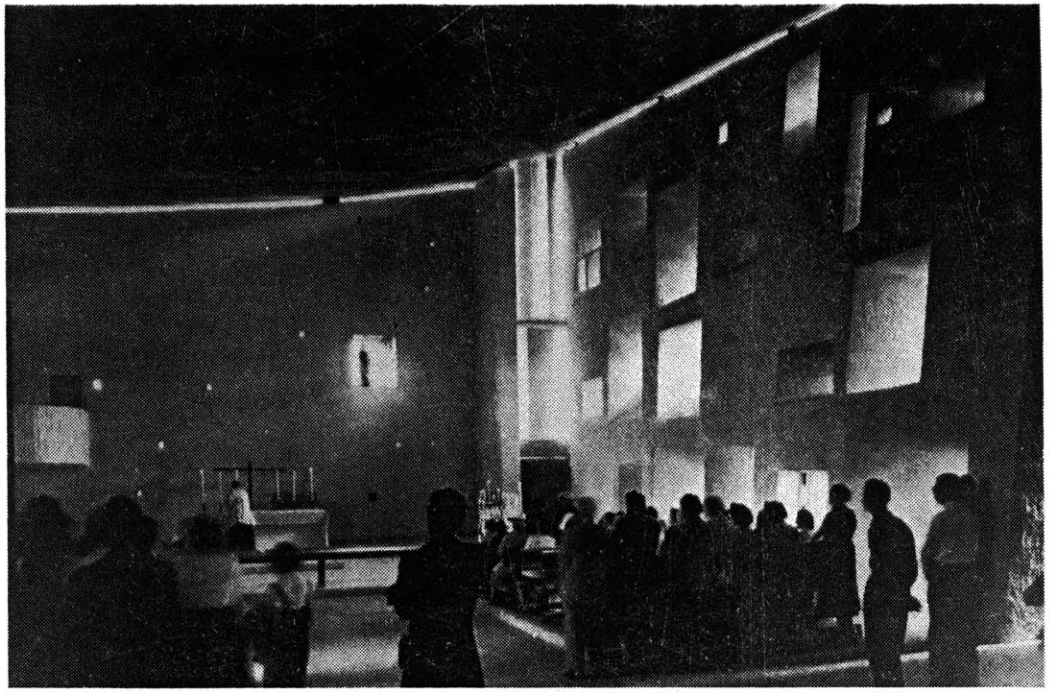
Eventually the Dessau Bauhaus abandoned this workshop.

Whether or not this adherence to "the sacred character of glass staining" was the attitude of the Bauhaus or of the general public (i.e., client pool) I have not been able to determine. However, judging from the completed works available for review which do not depict sacred images but rather show the direct influence of the contemporary de Stijl movement in painting I would suspect it was the latter. Nonetheless it seems that the art of stained glass at the Bauhaus was still being considered a type of painting, "painting with light" directed by leading figures in the contemporary avant-garde painting world. Considered "pictures" rather than fenestration (cf. Wright) the works undoubtedly did not find a place in the new concepts of space and form being developed.

3-22 Staircase window by Albers in Sommerfeld House, Berlin, 1922; architects Gropius and Meyer.



3-23 Pilgrimage chapel of Notre-Dame-du-Haut, Ronchamp, 1950-53.

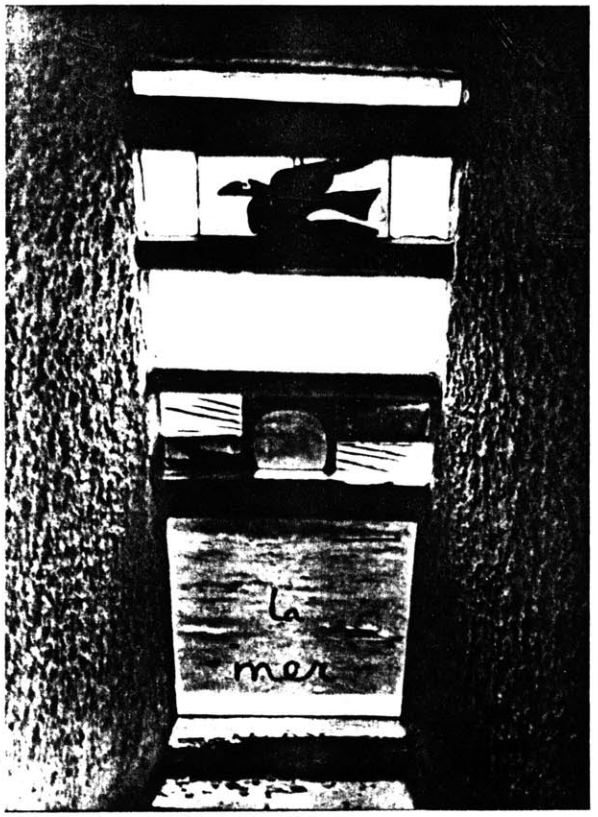


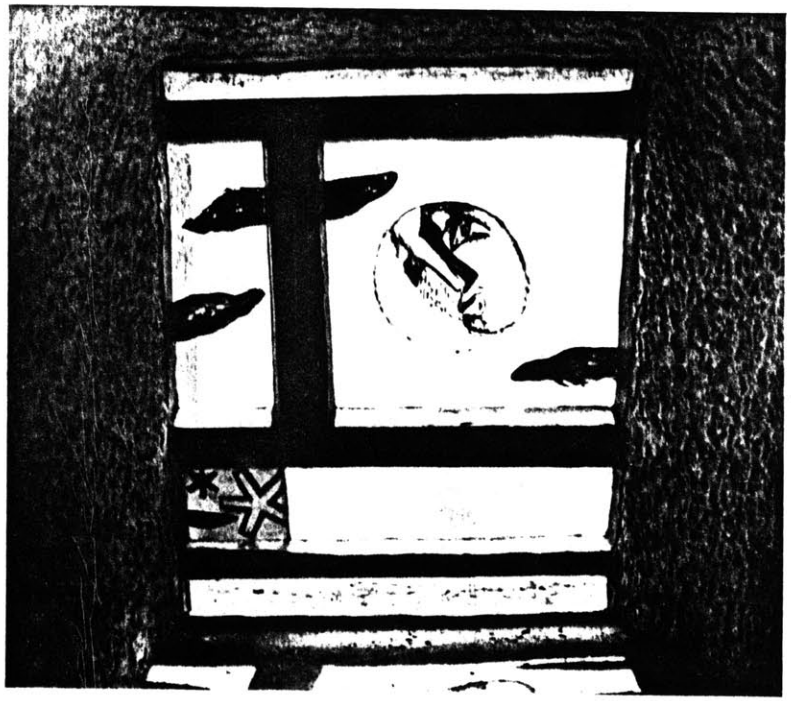
3-24 Interior of chapel showing windows of the south wall.

Le Corbusier

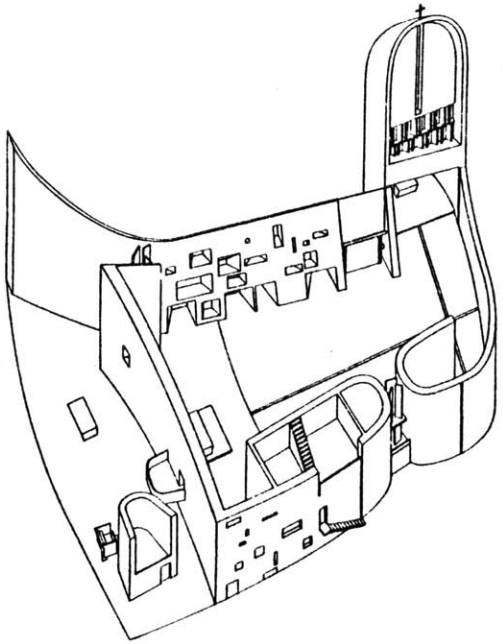
According to my research efforts the chapel at Ronchamp (1950-53) is the first building by Le Corbusier (1887-1965) where he used a form of stained glass. Many critics have claimed that Ronchamp is in direct opposition to Le Corbusier's previous work and ideas, if not a direct countermand to modernist architecture in general. Leaving behind the rationalist geometrical forms for which he is so well known the chapel is considered to be the first building in which Le Corbusier gave a plastic interpretation to an entire building.[37]

A part of the French clergy interested in spiritual reform had made contact with a number of modern artists (Matisse, Leger, Chagall) to effect a rejuvenation of religious art in France. As architect, Le Corbusier was given free rein to develop a new typology of sacred architecture and responded with an "atavistic mysticism of nature ... a sanctuary dedicated to nature."[38] At the consecration ceremony he declared, "The feeling of the sacred inspired our efforts. Some things are sacred, and others are not, regardless of whether or not they are religious."[39]



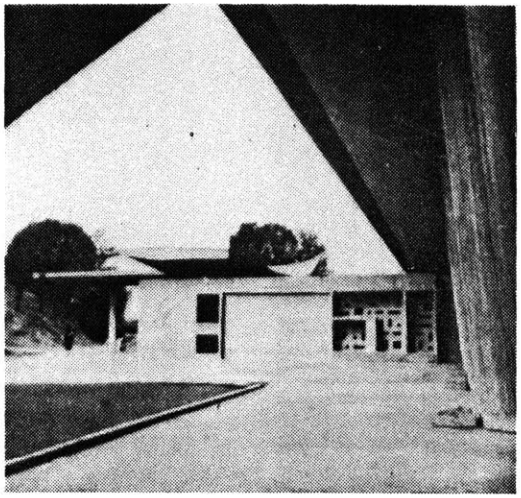


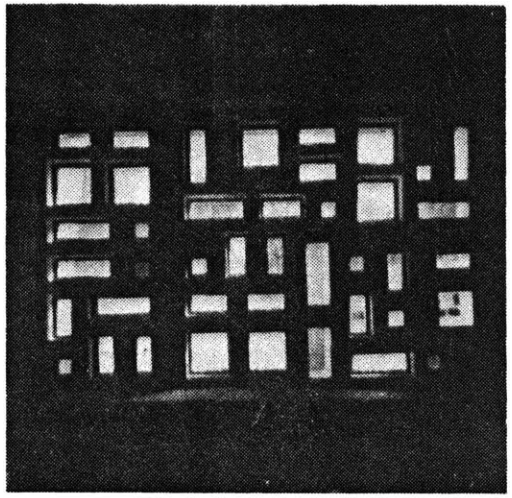
3-25 and 3-26 Windows of the south wall with painting by LeCorbusier.



3-27 Axonometric projection of Ronchamp chapel.

From the beginning Le Corbusier announced bluntly "Je n'aime pas le vitraux" (I do not like stained glass). Instead his is a very purist statement of clear colored glass with only a few primitive symbols and words painted by himself. Set deep within the 9-foot thick southern wall the effect of the windows is more a wash of colored light from unseen sources than an obvious decoration. Compared to Richardson's Trinity Church where color and embellishment are everywhere the strong molded forms of Ronchamp's white-washed walls and almost primitive windows underline the essential purifying effect of the modernist movement.[40]





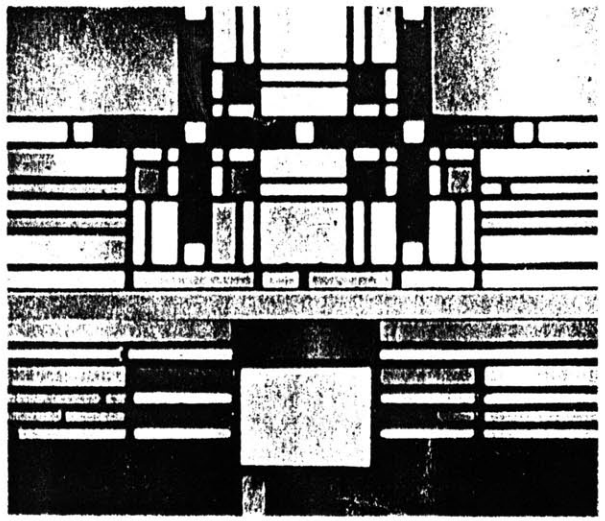
3-28 and 3-29 Apartment building in Marseilles by LeCorbusier, completed 1955. Exterior and interior views of glass and concrete screen in the foyer.

Design Qualities

In retrospect it can be seen that stained glass went through a cleansing period after its heyday during the American Renaissance. Tiffany and his colleagues of the era were, at heart, painters and craftsmen, not architectural artists. They were stretching the limits of the material as an illuminated painting applied decoratively to a building, not as an integral architectural element of the building. In clearing their structures of unnecessary baggage to get at the most honest architecture of their times the early modernists easily dispensed with such an applied extra. Wright's work with leaded art glass as integral ornament and light screen, short-lived though it was, was actually the harbinger of future work in the field.

"Post Modern" Revival

Johan Thorn-Prikker (1868-1932) is now considered the father of contemporary stained glass.[1] Thorn-Prikker, a Dutch artist working in Germany, had made observations similar to Wright's, particularly recognition of the importance of the pure nature of glass as a unique material. He challenged many accepted ideas about stained glass and argued that it should be devoid of figurative content and spatial illusion. He also felt it was vitally necessary to respect architectural requirements and for the stained glass to be integrally related to its setting.[2]



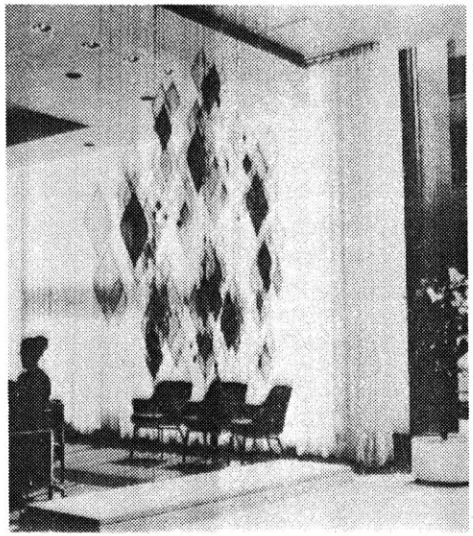
4-1 Window detail, Thorn-Prikker.

The devastation of World War II was the unfortunate cata-

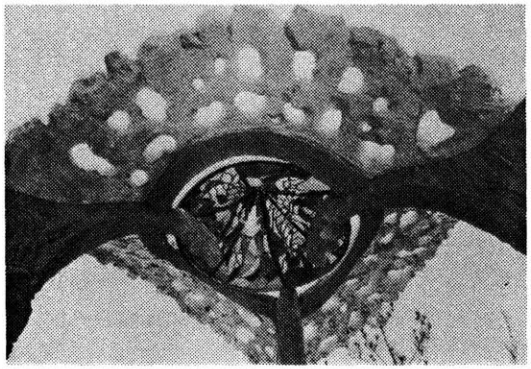
lyst which precipitated a focusing of attention on Thorn-Prikker's ideas. After the war whole cities in Europe as well as partial reconstructions on centuries-old cathedrals needed to be carried out. Many new public buildings were conceived at this time and found expression with the new generation of stained glass artists. Assisting this impetus was a tradition of generally enlightened arts patronage in Germany and a long and indigenous tradition of architectural arts and crafts which had not been subordinated to the fine arts.[3]

Contrary to the Bauhaus objective of combining both artist and craftsman in one person the most successful working relationship seemed to consist of a separation of powers between the stained glass artist and the skilled artist-craftsman operating the fabrication studios. It was recognized that there is usually a difference in temperament and interest between the two factors (design and production) of a successful piece. The long experience of master craftsmen allowed the artists to depend on the studios for technical knowledge and skill in producing their most innovative ideas. Both artists and craftsmen received formal training in architecture.[4]

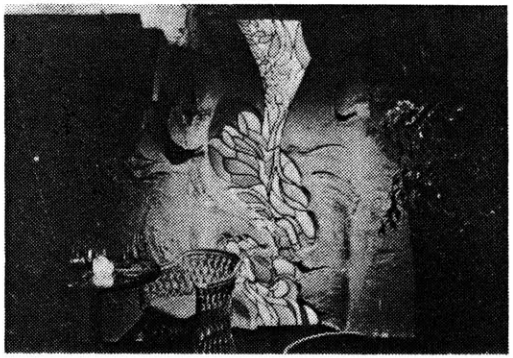
The Gothic revival of the American Renaissance was a revival within the confines of a pseudo-medievalism of culture and architecture. Stained glass artists of the period were interested in that medium amongst many other things as well. The German revival after World War II has accomplished more



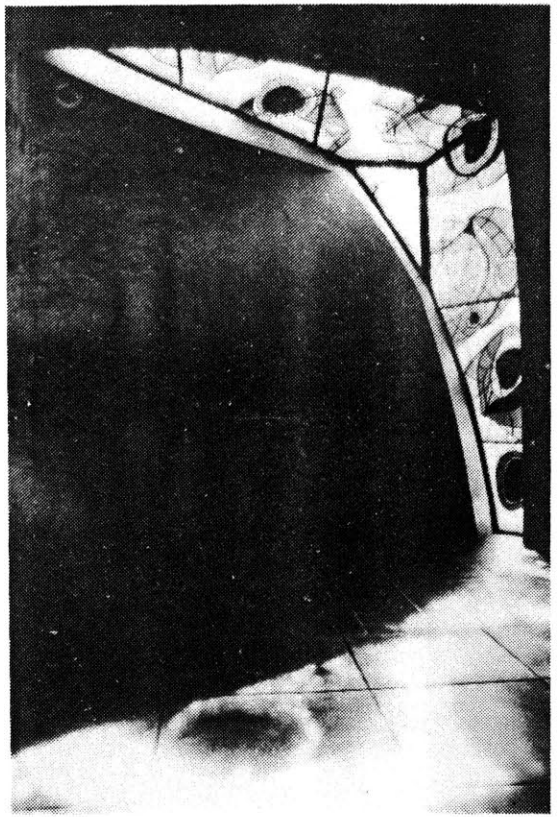
4-2 Space divider.



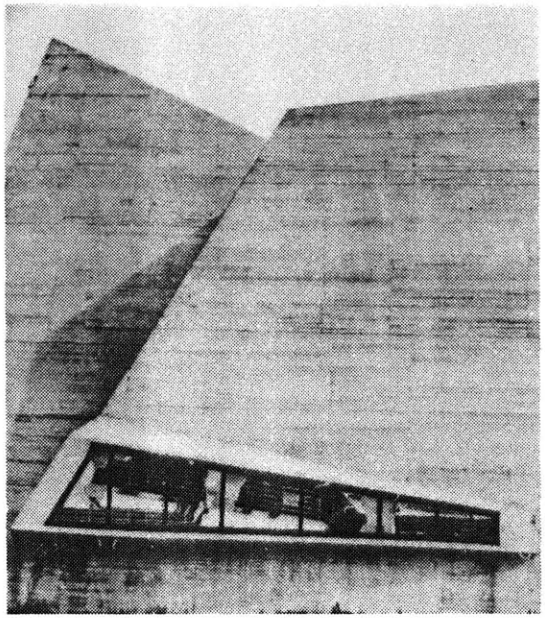
4-3 Sunscreen in concrete pavilion casts moving colors on the ground.



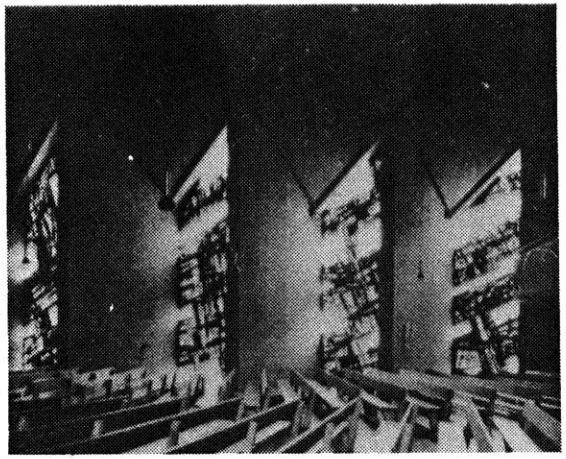
4-4 Free form glass and concrete wall.



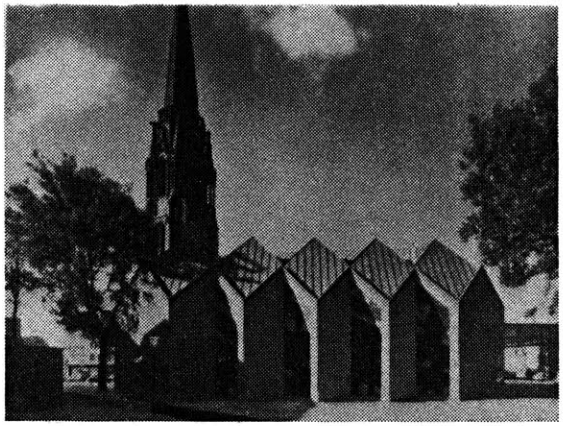
4-5 Stained glass opening continued through wall and ceiling.



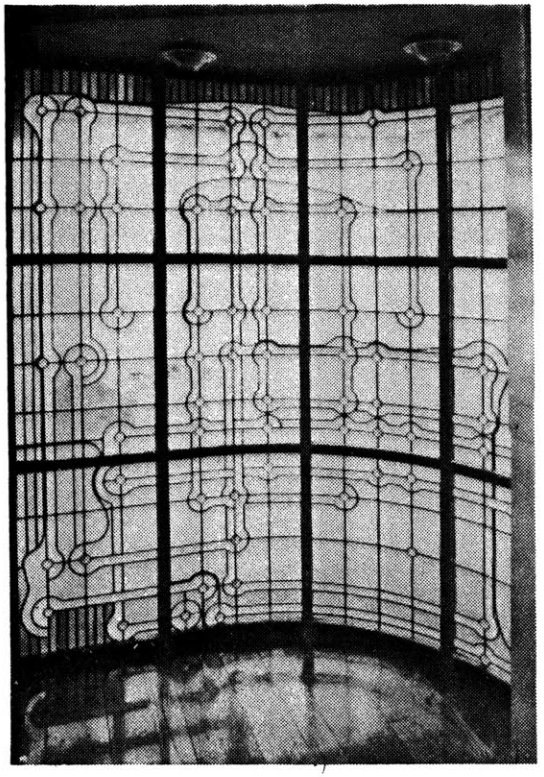
4-6 Ludwig Schaffrath, 1971.



4-8 Christ Church, Boehmm, Germany, Dieter Osterlen architect.



4-9 Christ Church, Boehmm, exterior.

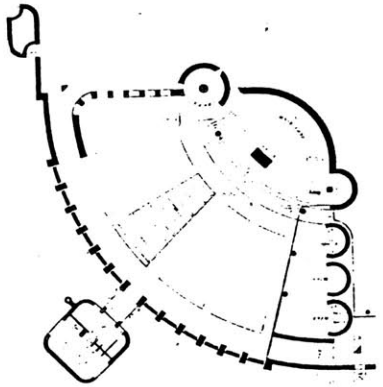


4-7 Clyde's Restaurant, Vienna, Virginia, by Kenneth von Roenn, 1980.

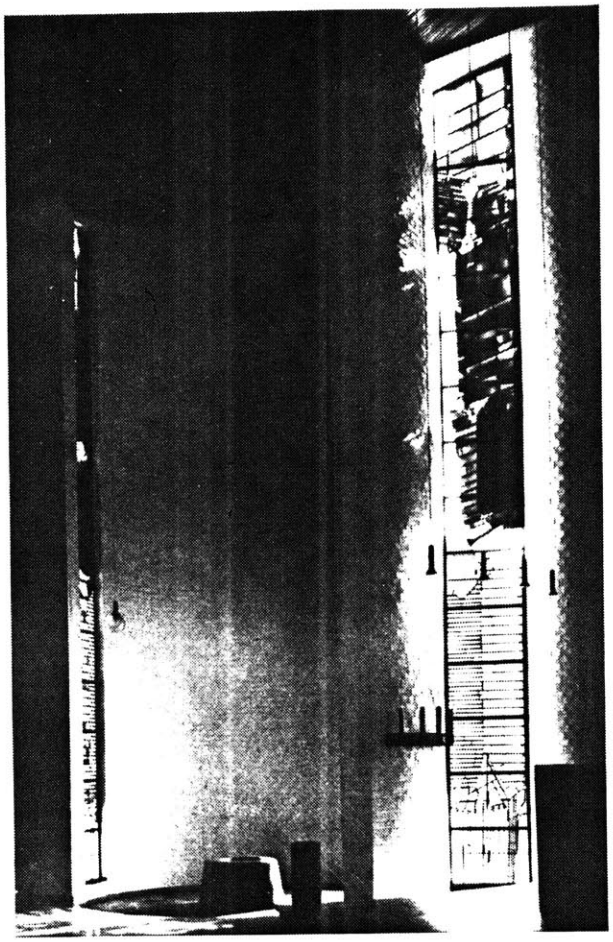
significant progress by returning to the truly basic properties of the medium itself: glass as a material, graphic composition of the connective tissue and attention to the behavior of light. It is doubtful that these shifts in understanding could have been accomplished without the challenging re-evaluations of art and architecture demanded by the modernists. The result has been a new ability to exploit the contemporary possibilities of fenestration. Of course it is still possible and at times even desirable to design an easel painting in glass but the new emphases have allowed the re-emergence of stained glass as an architectural art that can speak in the contemporary idiom. Although color still plays an important role, value and texture are seen as equally significant. Perhaps paramount in the new language is the exploration of the leadline as a major design tool in producing new forms.

Discussion of Design Qualities

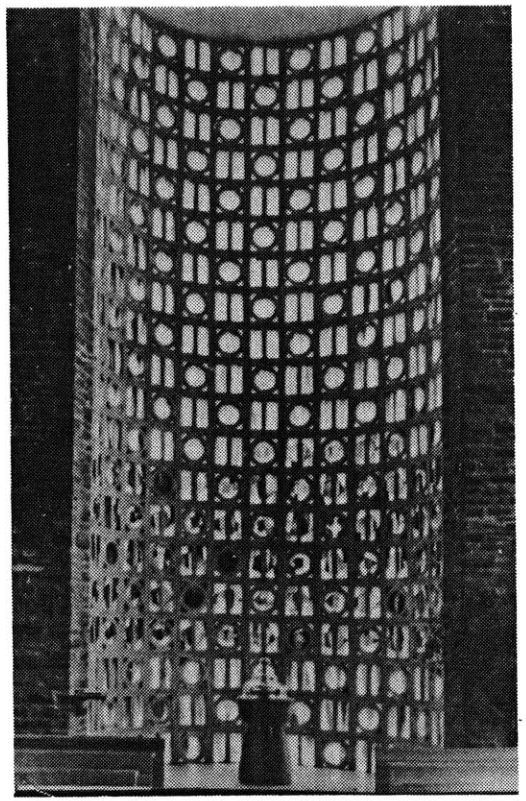
The critic Robert Sowers has characterized the stained glass artist as a "lighting engineer" who must work in conjunction with the architectural design of spaces and openings.[5] As an art of the wall the province of stained glass is the whole scope between solid and void, between the punched window opening of a masonry wall and the sheer glass curtain wall of a steel skeleton structure. Within the hierarchy of forms the stained glass can be a greater or lesser part of the whole. For



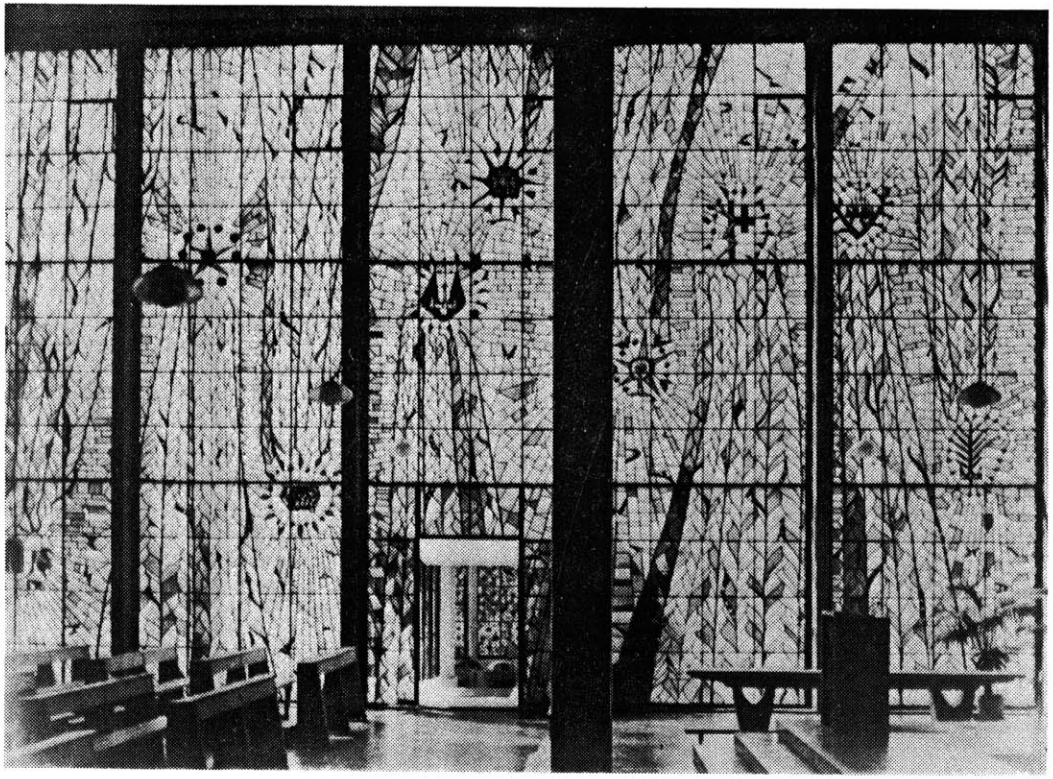
4-11 Plan of St. Bernhard's.



4-10 Ludwig Schaffrath, St. Bernhard's, 1966.

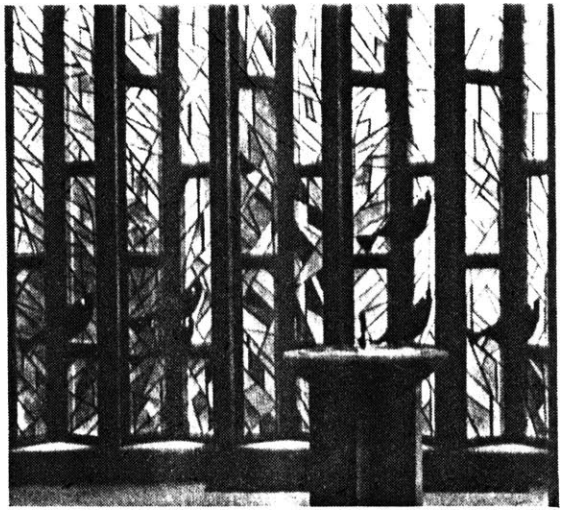


4-12 Baptistery window, Ludwig Schaffrath, 1954.



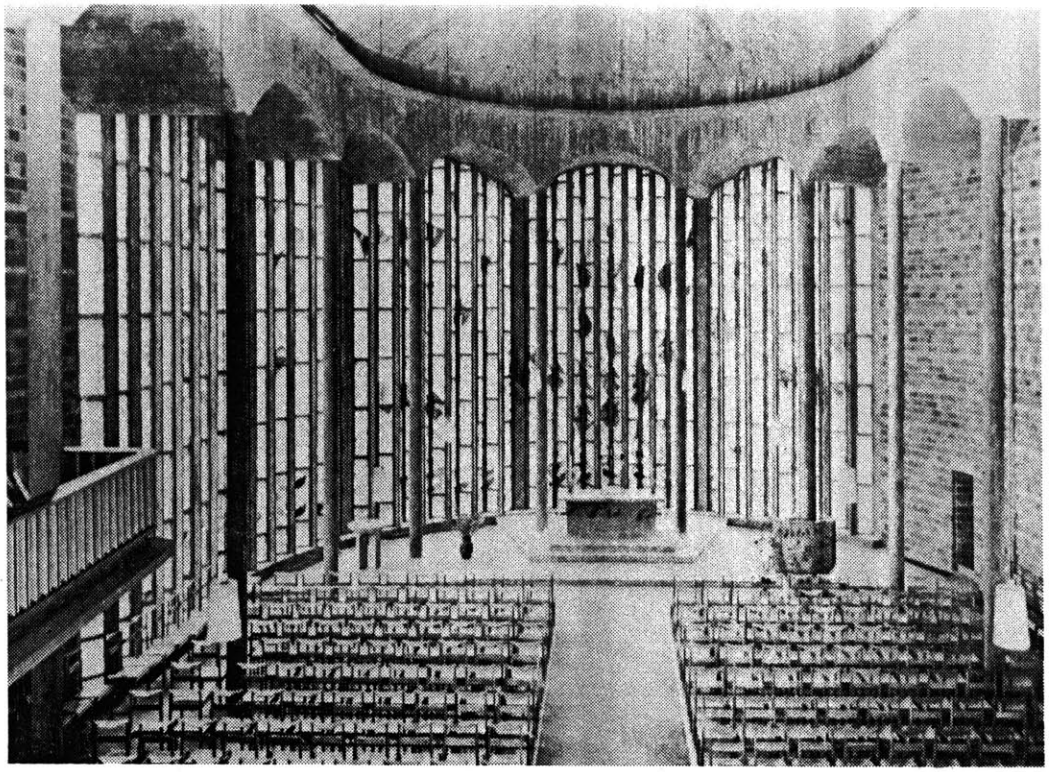
4-13 Church of Maria Konigin, Cologne, 1953.

instance in Ronchamp the windows are subservient to the overall statement of architectural form; their crude primitive style supports the primordial spirit of the chapel. At the Church of Maria Konigin in Cologne (1953, architects Dominikus Bohm and Heinz Bienefeld) the stained glass is a primary element of the architectural form. It creates a veil of shimmering light which seems not quite solid, thereby achieving a totally different quality in the space.[6]



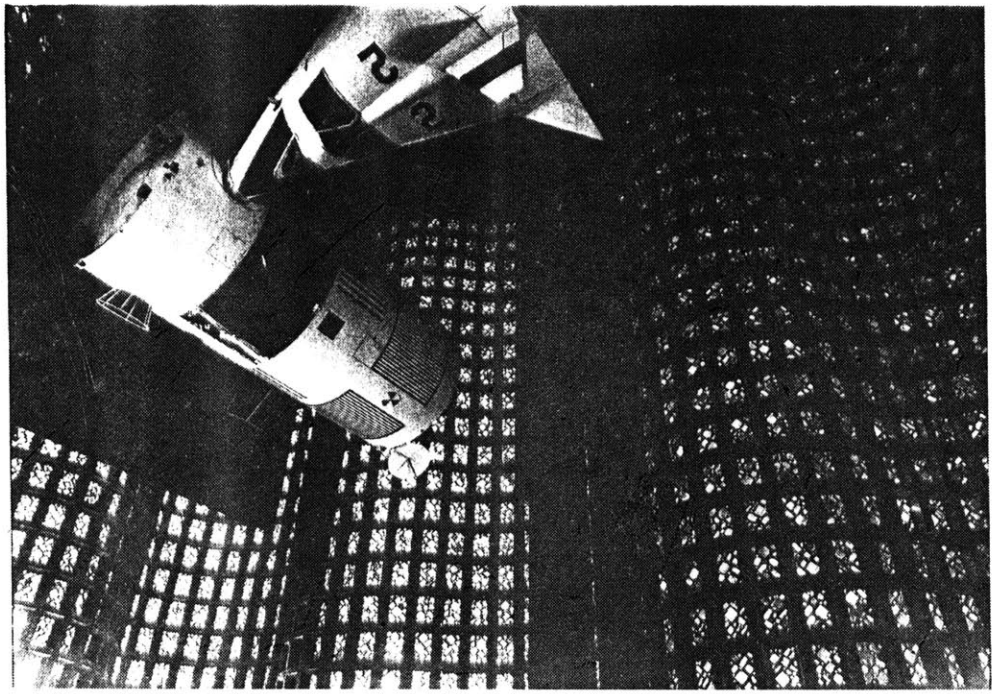
4-15 Detail of St. Ludwig's.

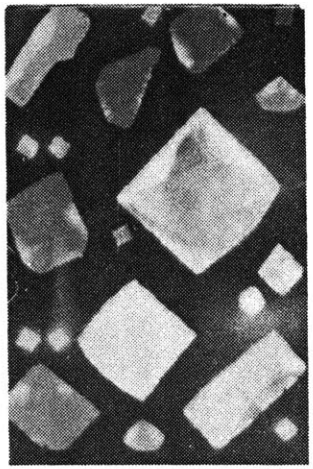
4-14 St. Ludwig's Evangelical Church, Freiburg, Germany. Stained glass wall as major element of the architectural form.



The architecture to a large degree determines how luminous, or bright, the stained glass can be. In its role as modifier of natural light the material is susceptible to the effects of certain "light ratios" which are not commonly understood.

> First, only so long as more light comes through stained glass from the outside than falls on its surface from inside the room can we see through the glass and thus see its colours and patterns illuminated. Second, the darker the glass the less light can come through it; therefore the less light it can tolerate on its inside surface





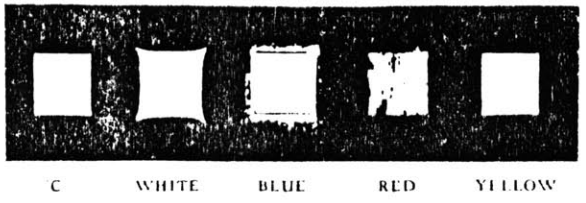
4-18 Detail of the "dalles" at Hall of Science.

4-17 New York Hall of Science, 1964. 80' high wall of blue "dalle-de-verre" (inch thick slab glass) and concrete.

> without losing its luminosity. Third, not too much more light must be allowed to come through a stained glass window than the eye is normally accustomed to in the given interior or the effect is harsh and glaring.[7]

Thus, darker interior spaces require a more deeply colored glass, and more open spaces require lighter values and more delicate coloring of the glass.

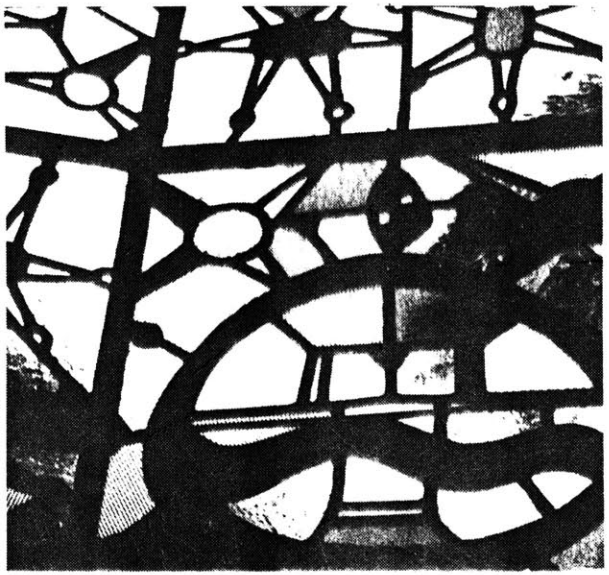
Colors themselves have been long misunderstood in stained glass. Studies have been done trying to analyze the apparent power and intensity of the colors in the most effective medieval windows. It seems evident now that the greater energies are not



4-16 In Vitrail Viollet-le-Duc studied the radiation qualities of different colors. His theory was later disproved.

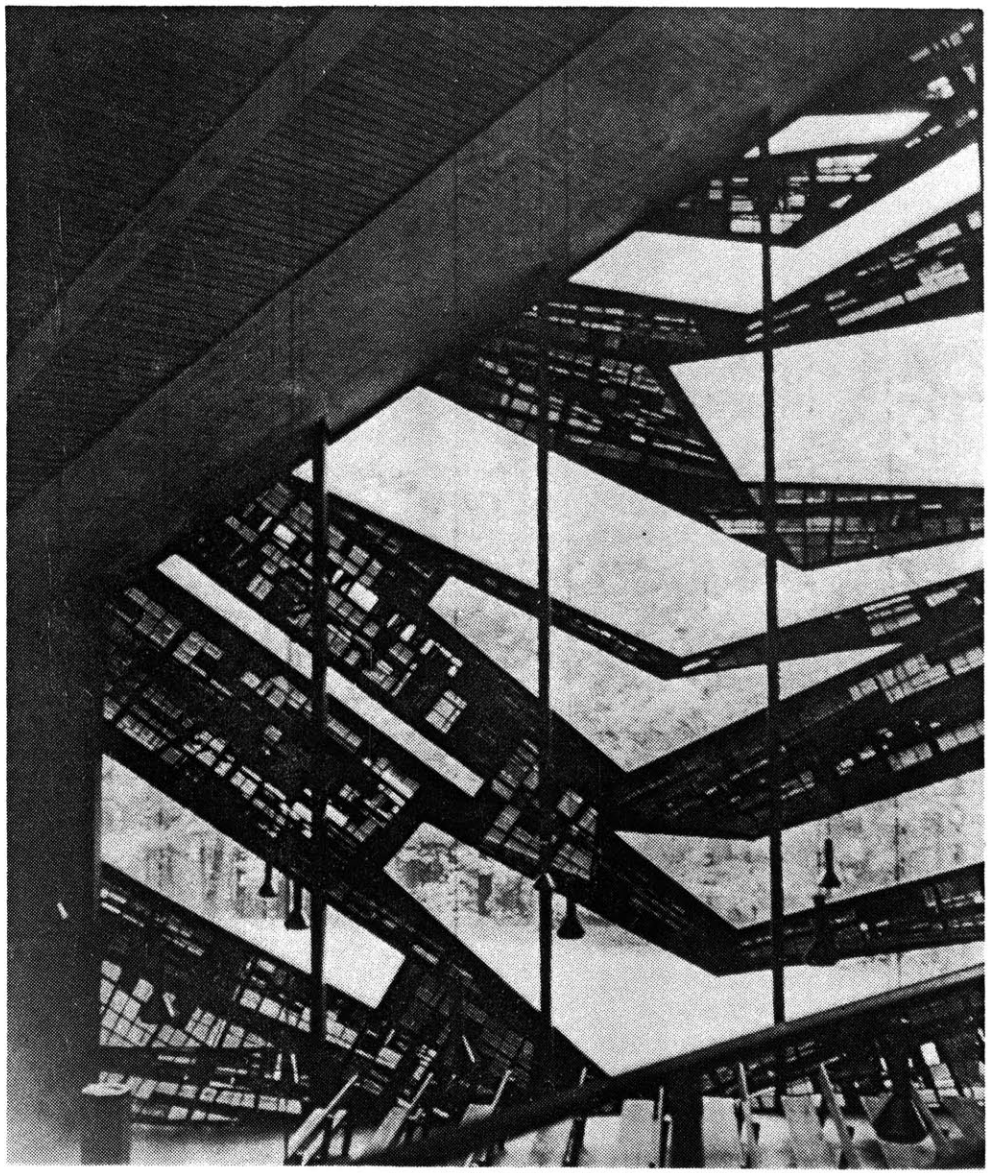
due to particular colors but to contrasts in value.

> It is the luminosity, the vibrancy, the almost respiratory value inflections of the glass rather than the color itself to which [the viewer] is largely responding; ... for ultimately, color in stained glass is dispensable while these other qualities, which are so immediately and finally compelling, are not. Its most singular effects, its vital import, its primary role as an art form, all derive in the last analysis from the cultivated play of natural light.[8]

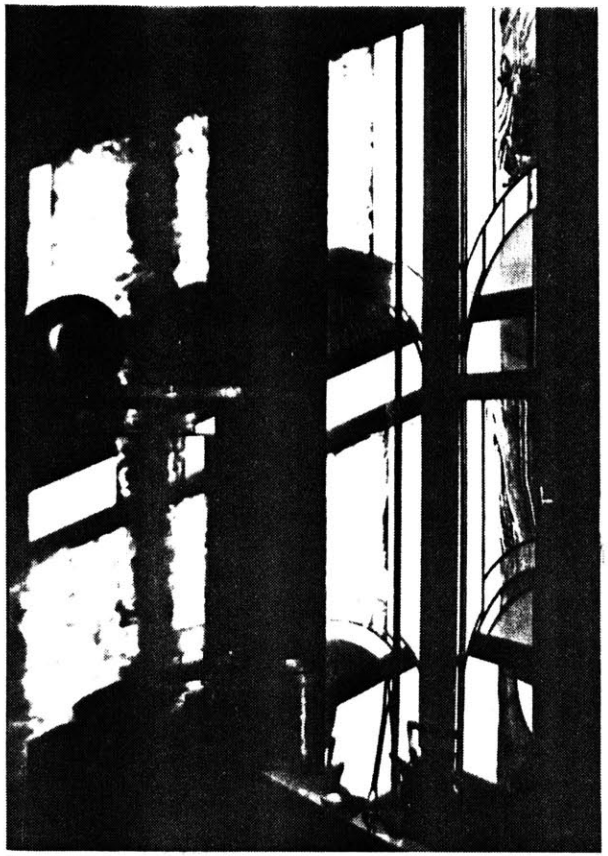


4-19 Detail of various textures of glass used at Maria Konigin.

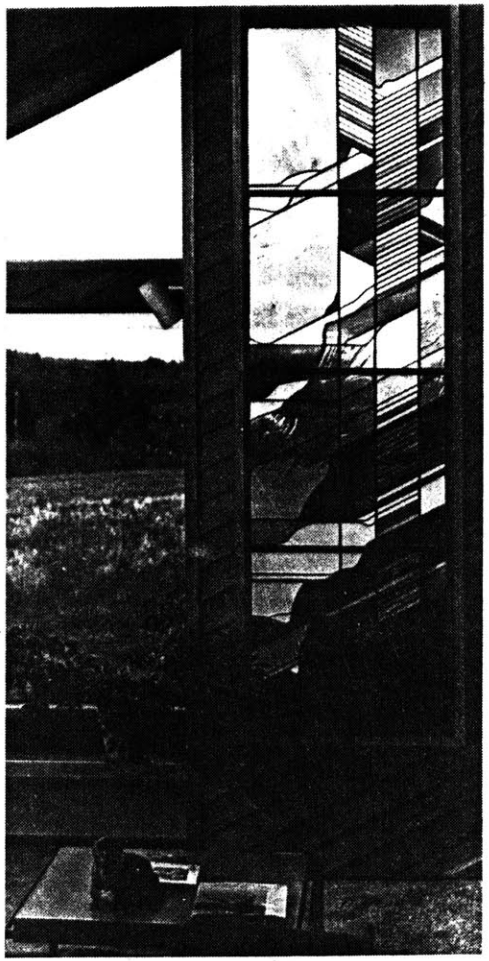
Brilliance or luminosity of light is determined by the refraction factor of the glass. Refraction, the bending of light rays, is caused by surface textures. As the angled side of a prism will bend white light into a spectrum of colors, so will surface variations of any glass distort the light rays passing through it. The brilliance of antique glass is due in part to the imperfections of its manufacture and also to the superficial patina of many minute scratches gathered from centuries of weathering. The cheapest machine rolled modern glass is flat and thin and therefore has little refraction quality. However, machines can also press mechanical patterns into the glass creating numerous light catching facets on a larger scale than the surface irregularities of antique glass. The Church at Maria Konigin uses a large proportion of this economical machine-pressed glass to complement the more subtle refractions of antique type glass.[9]



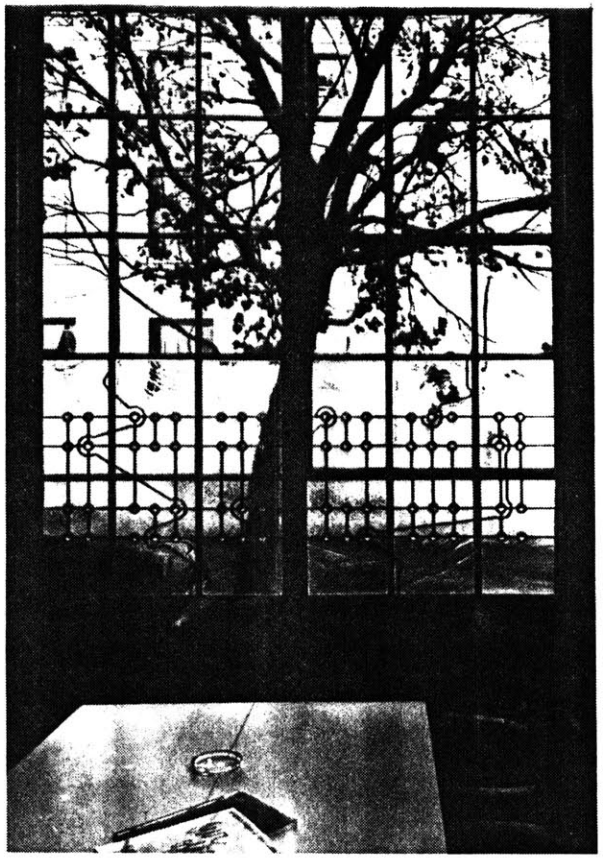
4-20 Christ Church in Sennestadt, Germany, architect Dieter Osterlen.



4-21 Residence, Brooklyn, New York, 1980. Glass by Robert Sowers.



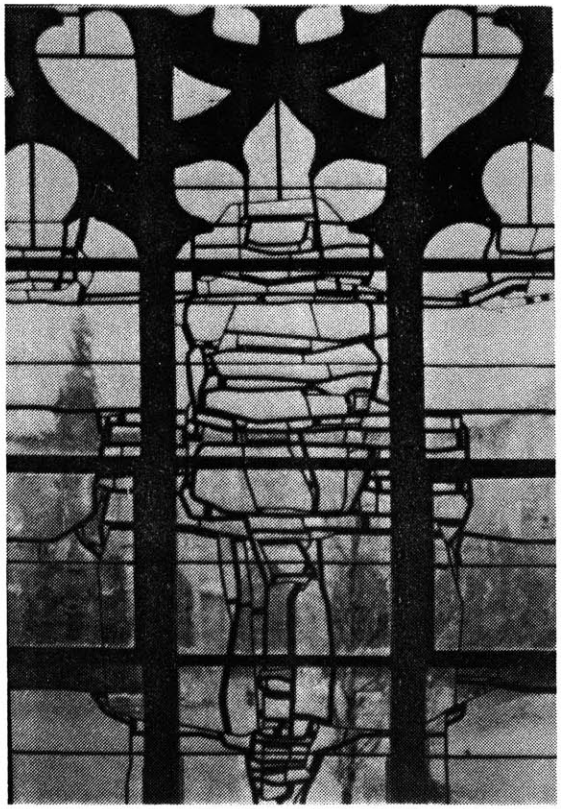
4-22 Residence, Portland, Oregon, 1976. Glass by Ed Carpenter.



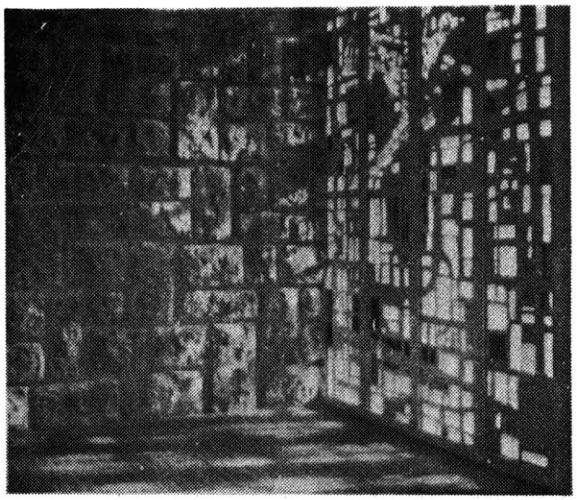
4-23 Architect's Conference Room, San Francisco, by Peter Mollica.

The most inherent quality of stained glass is its transparency. Transparency is the capacity of a material to transmit appearances; translucency is the capacity to transmit light; opacity admits no light at all. All glass is on a continuum between transparency and opaqueness relative to other pieces of glass but also relative to itself under different lighting conditions. This leads to a particular three-dimensional characteristic of stained glass which distinguishes it from any other mural art. The stained glass is actively and directly engaged with the luminous visual field behind it. It is affected and constantly changed by whatever is behind it that can reflect light. This could be the daily cycle of direct sunlight, changing cloud patterns, trees blowing in the wind, passersby, or even stationary objects such as a nearby building.[10] The more opaque the glass is the more controlled is the light which passes through it. More transparency contributes to a more screen-like effect and a continuity of affect between inside and outside.

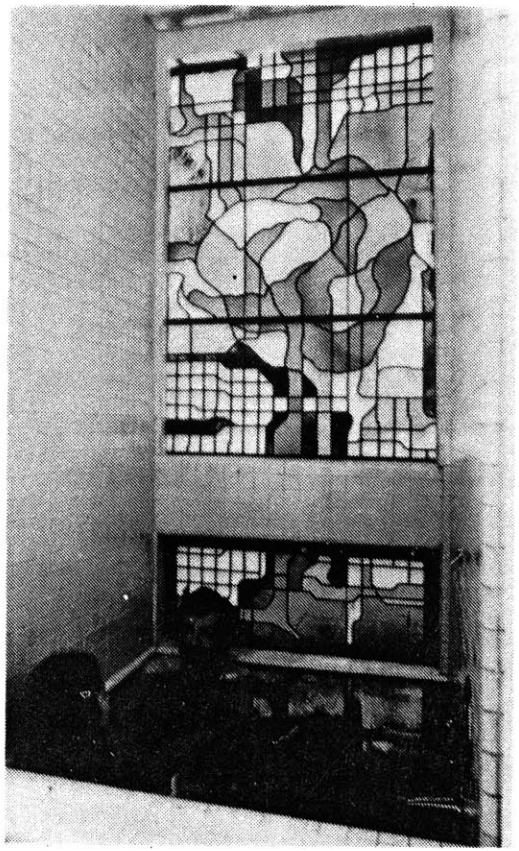
The graphic structure of opaque leadlines is the second most integral design quality of the stained glass window. The greatest medieval cathedral windows had a flat mosaic quality which incorporated this graphic patterning easily. They predate the emergence of painting as the dominant art. By the sixteenth century stained glass had been forced into trying to reproduce paintings (as were also mosaicists, tapestry makers, and illum-



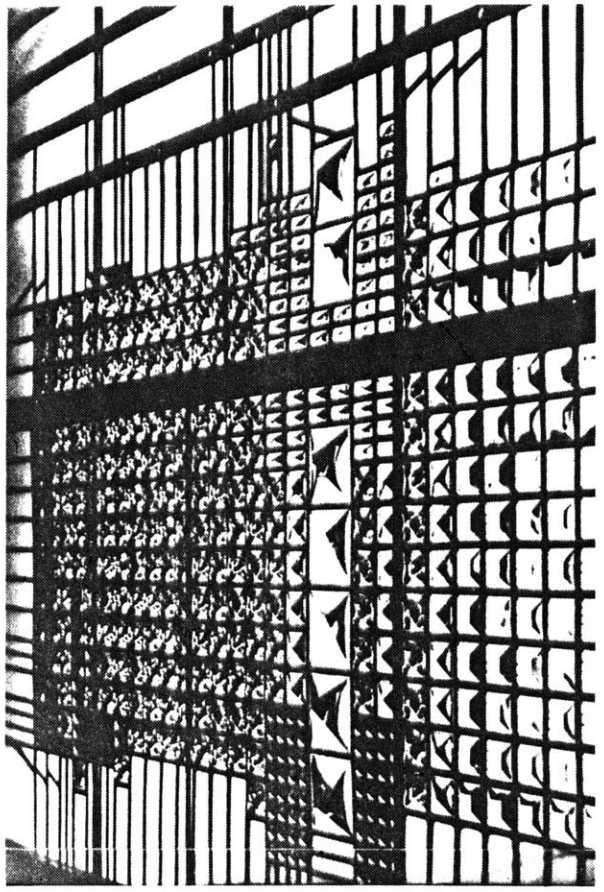
4-28 Cloister window at Aachen Cathedral, Ludwig Schaffrath, 1962-5. Schaffrath is considered the leading master of the leadline. He often uses colorless glass varying only in texture and value, as shown here.



4-24 Slab glass in concrete reflecting on stone wall surface.



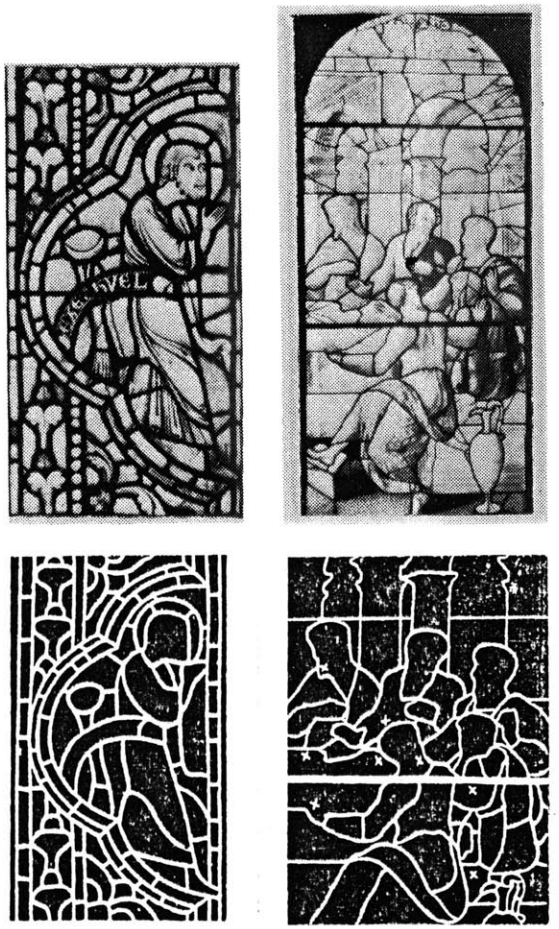
4-25 Glass screen window in tiled bath.



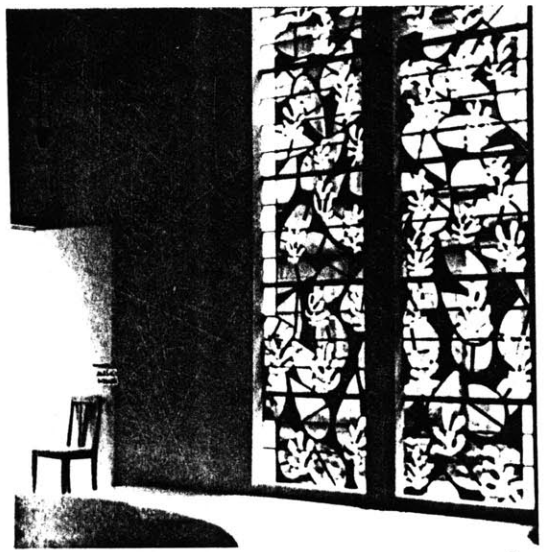
4-26 Prism window, Ludwig Schaffrath, 1968.

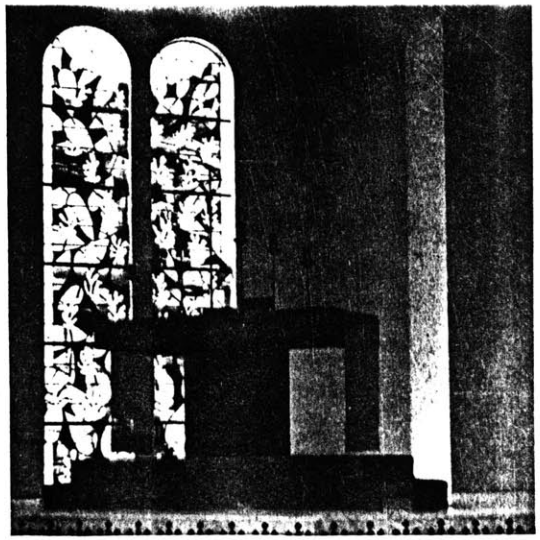
inators). However, for "paintings" the leadlines were a tiresome confinement. They could not be done away with for structural reasons yet they could not be made invisible enough to serve an illusionistic art. Attempts were made to "hide" them in the outlines of figures but this was never a satisfactory compromise; it only served to destroy the cadence of a design.[11] Wright and the later German revivalists re-established the importance of this integral structure when they rejected literal representations and returned to abstract designs. Contemporary designers have gone beyond geometry to organic forms and engaging spatial relationships. These graphics can be a strong tool in shaping the mood of an interior space. When cast slab glass is used with concrete the formed concrete structure performs the same function on a larger scale.

Unlike Tiffany, LaFarge, et al., most contemporary stained glass artists avoid scenes of pictorial reality. To achieve such representation requires the depiction of light and shadows within the scene to create three-dimensional illusions. These illusory light effects compete with the real light that illuminates the window. In an effort to control the light and shadow of the picture the real living light is often forced into static submission, or even extinction. To draw the viewer's attention off into some limitless imaginary space ignores the capacity of the material to transform the space the viewer is actually in at the moment.[12]

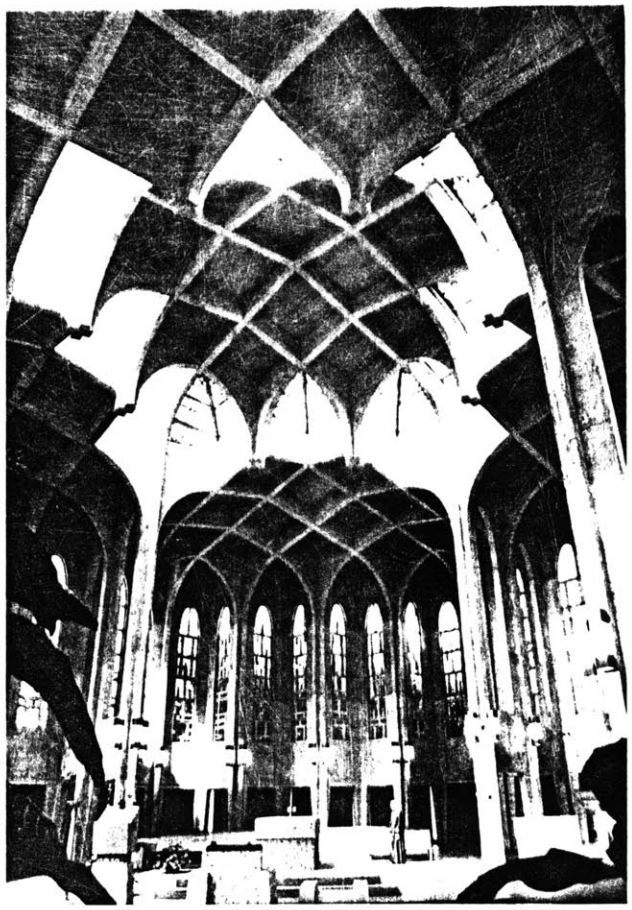


4-27 "Ezekiel" and "The Last Supper." In the former the structure of the leads creates a formal pattern in which the subject can exist; in the latter, a chaotic formlessness of leads.





4-29 Chapel of the Rosary, Henri Matisse, 1947-50.



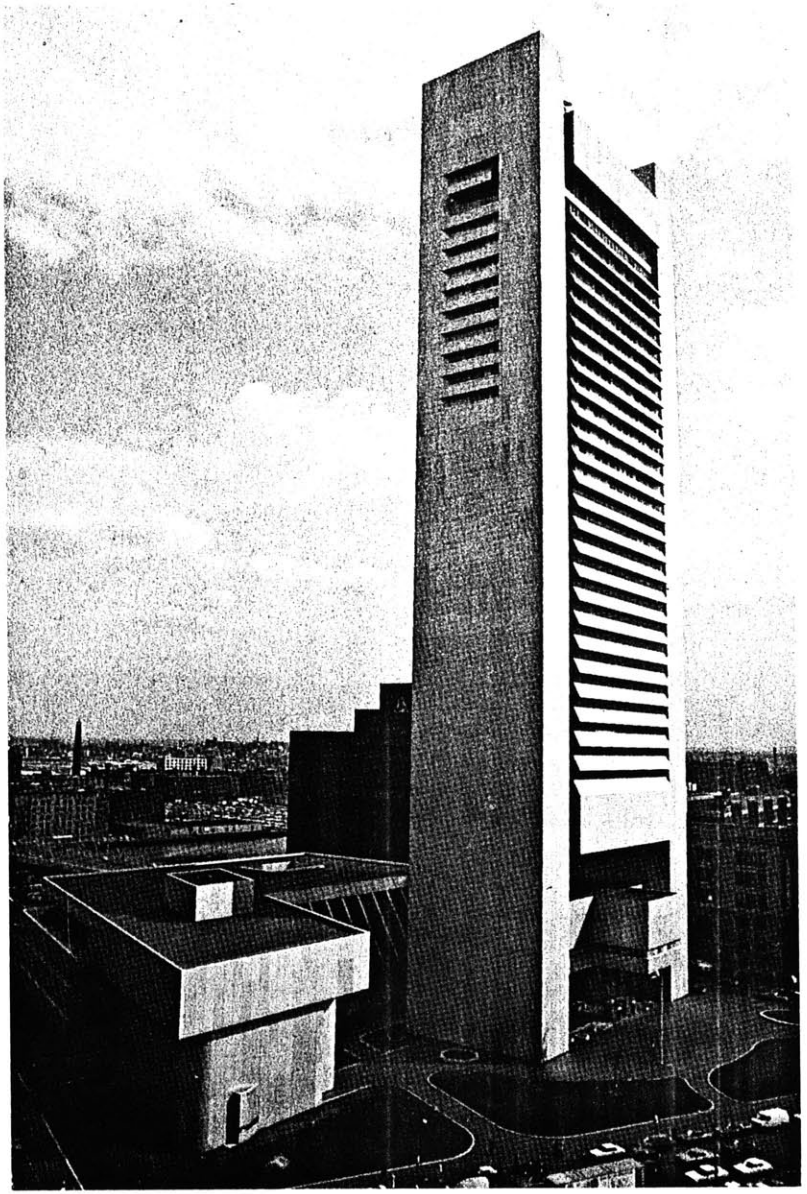
4-30 Westminster Abbey Church, Mission, British Columbia, Asbjorn Gathe architect, 1983. The stained glass forms an integral part of the structure with the concrete.

Sketch Problem

Designing stained glass is beyond the scope of this thesis. The point of the thesis has been to arrive at a more useful understanding of the opportunities and limitations of the material from an architect's point of view. Rather than design the work personally an architect would engage a stained glass designer who could bring greater experience and technical skill to the problem. As with all consultants we will get better results if we understand the parameters of a situation and can communicate effectively on the pertinent points. Consequently the sketch problem is used to illustrate the design issues an architect should consider when engaging a glass artist on a project. Involving the designer as soon as possible will yield the most productive outcome.

The Federal Reserve Bank in downtown Boston, across the street from South Station, is typical of many sleek modern office buildings with tall towers and a huge glassy public lobby space of rather undifferentiated character. Completed in 1977 the 604 foot tower contains 33 storeys of office space annexed to a four story operations wing. The steel structure is sheathed in a curtain wall of anodized aluminum panels from top to bottom. Aluminum spandrel "eyebrows" shade the horizontal bands of glass in the summer and form the only textural articulation of the building. The tower houses bank administrative

4-31 Boston skyline with Federal Reserve Bank to left.

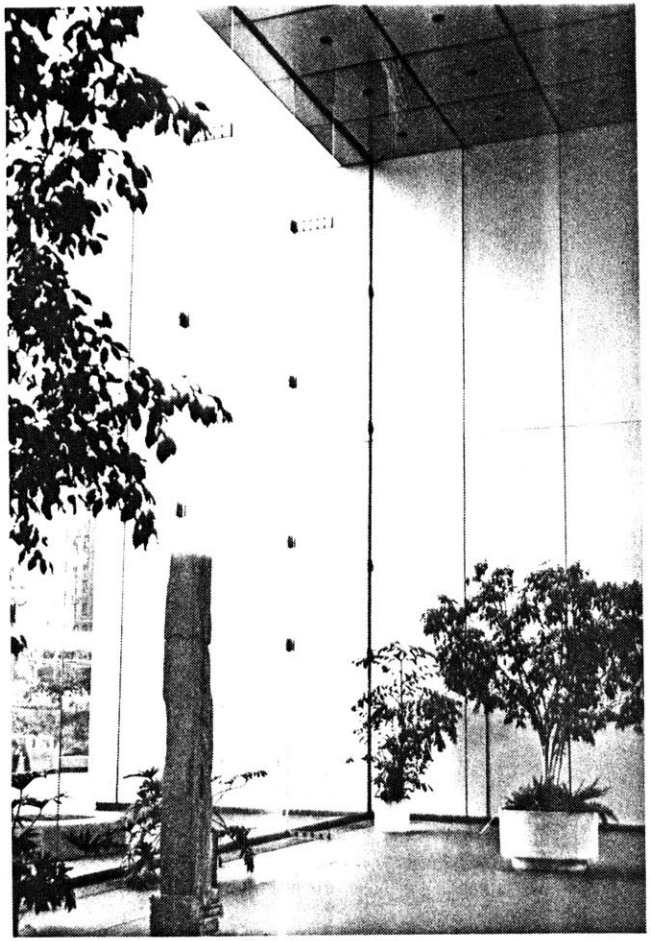


4-32 Administrative Tower, Operations Wing, and Plaza from Atlantic Avenue.

functions and leased office space while the operations wing requires tighter security for money-handling operations. The bank makes an effort to contribute to the public environment with a large plaza landscaped with grassed embankments and trees and benches. Beyond the lobby on the first floor of the operations wing is an art gallery open to the public.

The lobby space under the tower maintains the monolithic feel which the building as a whole has from a distance. A rectangular space of 140 x 56 feet it is bounded by aluminum or glass panels on its four sides. A guard station just inside the doors plus a security block on the jutting mezzanine level remind one of the purpose of this place. Primarily the lobby is a vast expanse of space to be traversed on one's way to the elevator cores at either end. One feels rather miniscule and unprotected and not inclined to linger about. The glass walls were apparently designed to be as invisible as possible, a transparent membrane set in place to keep the weather out. There is no steel structural system supporting the glass pieces. Instead the 10 x 12 foot one inch thick panels are butted together and held in placed with small metal "wing mullions." Lateral bracing is provided by additional glass panels attached at right angles. It seems that the glass wall is trying to appear as non-existent to create a virtual continuum between indoors and outdoors but can't quite pull it off.

To acknowledge the glass wall for what it is and to create



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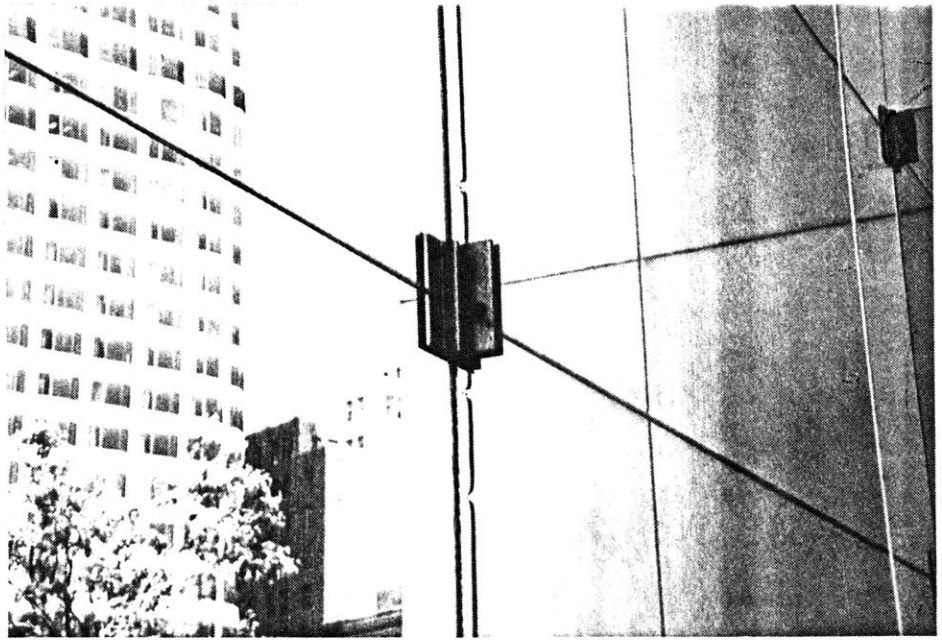

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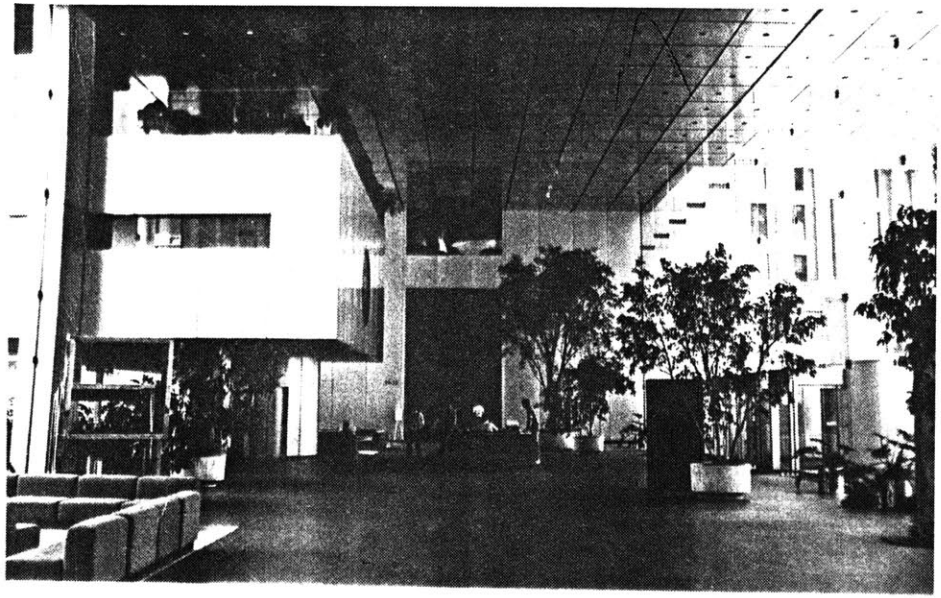
4-33 Approaching the tower.

4-34 Detailing of lobby surfaces. Note glass bracing applied to curtain wall.

4-35 Metal "wing mullion" used to secure 10' x 12' panels of inch-thick glass.



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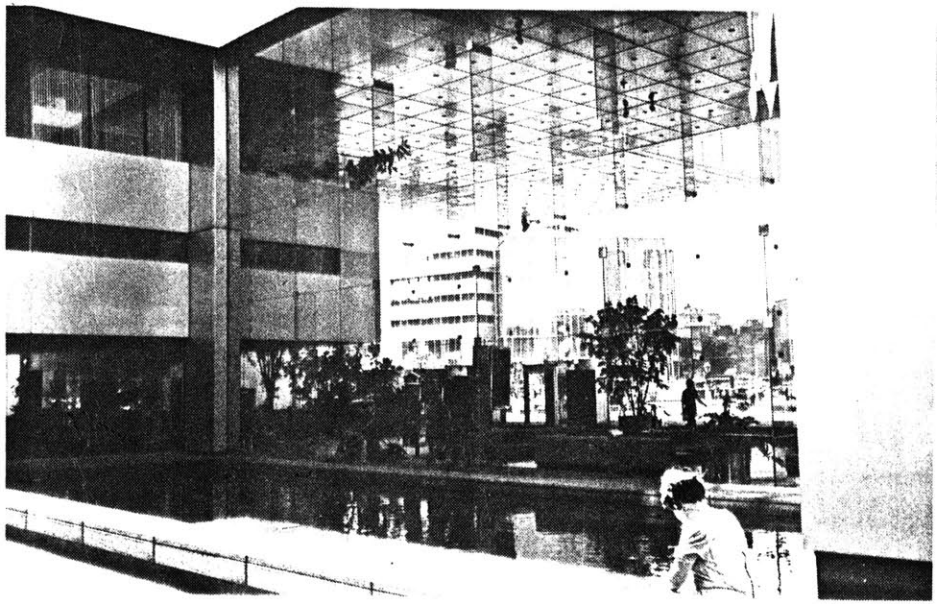
4-36 Interior of lobby space.

4-37 Looking through the transparent lobby from the path at rear to the plaza in front.

4-38 A glass curtain wall is not really invisible when it reflects the surrounding environment.



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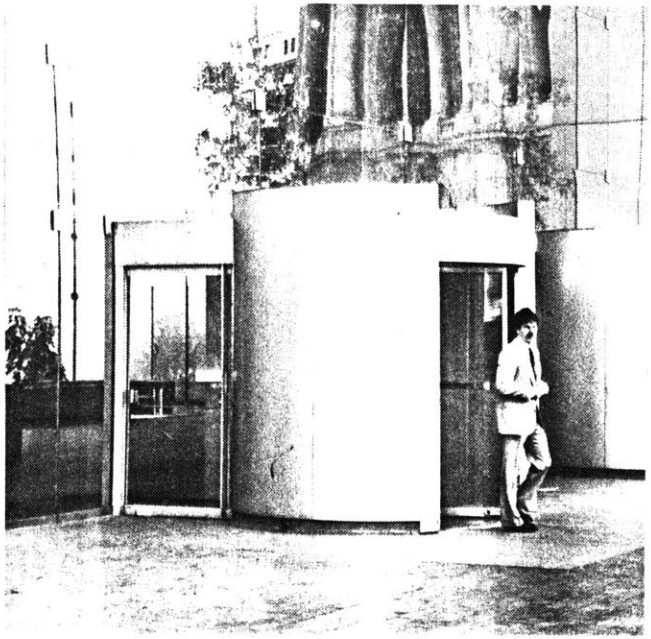

38

a more articulated human scale surface at pedestrian level a more complex glass design could be considered. The glass wall is there and with its reflections and tacked on bracing does not succeed in being invisible. It would seem a better solution to accept the glass for what it is and turn its structural limitations into advantages. It addition, while the monolithic image of the project is pleasing from a distance it offers very little of interest up close at the human scale. The monumental moves of the project are overwhelming when experienced at this level. A more articulated glass wall could help the individual begin to relate to manageable pieces of the whole.

I have synthesized from the thesis exploration four major issues which the architect should consider when approaching the glass. First, what is the attitude of the work to be? What is the stained glass to accomplish in mood and feeling for the space? Second is the issue of transparency -- how does the interior space relate to the outside? Third is the combined issue of subject matter and graphic structure. Should the work depict literal images or abstract patterns and how do these support the architectural statements? Finally, consideration must be given to the use of color and values in the fenestration. Is color appropriate and if so what and how much? What are the light ratios operating here and how should they guide the design to avoid unpleasant contrasts?

Attitude

The overall tone of the building is one of smooth efficiency and strength. The Bank, after all, is an institution in which one would like to have complete confidence and trust. Flamboyance or provocative turmoil would be out of place here. Energy and a lively sense of ordered movement would not be. The glass design should begin to break down the large scale moves so that the individual feels he or she has a place here. A more patterned glass wall could help dispel the anonymity of a huge expanse. The glass design should reinforce the sense of screen, a dividing wall which is there and articulated as such but also allows transference between inside and outside.

Transparency

The lobby space is one of two voids articulating the intersection of the low-rise operations wing with the tower. Its transparency is an important element in the gesture of welcome which the Bank extends to the public. It is important that the public can see into the building and that persons inside can enjoy the landscaped plaza and a connection to the outside. The lobby is a major transition zone between life on the sidewalk and the secured bank operations within. In addition there is a lot of movement outside the glass as employees and visitors use three separate entrances in different locations. This could be exaggerated in the distortions caused by clear but wavy textured

glass, emphasizing the busyness of the plaza. Along with a major emphasis on transparency, sections of heavier translucency could be designed to mark smaller areas within the large overall space. These would afford some sense of enclosure for sitting, waiting, etc.

Graphics

The Bank building as a whole makes a very clean streamlined statement. There is a complete absence of decoration or ornament anywhere except for the two abstract murals squeezed between the elevator banks. This would suggest that any literal representations would be out of place. Jagged or disturbing images would not be suitable at an institution required to inspire trust and confidence. Perhaps most appropriate would be a fairly ordered pattern of smooth lines whose orientation set them in opposition to the stolid rectangularity of the building. Curved forms or arches would also create a lively counterpoint. Graphic form could also be used to articulate areas within the larger space and to signal entrances.

Color/Value/Light

Given its lack of solid enclosure and 35 foot high ceiling the lobby is naturally a very well-lit space. East and west exposures mean that both faces of the lobby undergo a significant change in lighting level during the day as the sun travels

from one side to the other. This will cause the intensity of colors and values to change dramatically. The interior of the space remains relatively stable throughout the course of the day. If a large amount of clear colorless glass is used to maintain the transparent continuum between inside and outside this light level will remain high. To avoid glaring contrast, glass of lighter values should be used primarily. The aluminum sheathing of the building is of such a light color that heavy tones in the glass should be used judiciously or they may overpower the architecture. Careful thought should be given also to the selection of colors. The existing building is almost white in the sunlight and floor and ceilings are grey. Color could either be a useful accent or a raucous distraction. One could continue the colorless aesthetic and employ colorless glass of different textures and opacities to create the composition.

Conclusions

In this thesis I have attempted to better understand the place of stained glass in architecture. It is an element of medieval origin and yet it is constituted basically from the same materials which make up our twentieth-century glass curtain walls. I was curious to discover if this traditional material could have any role to play in the modern world, or if its relevance was truly outmoded. Glass is used extensively in contemporary architecture and color has been restored to a significant position by the Post-Modernists. Light behavior and its role in shaping one's perception of space have always been crucial to architects not overly enamored of the wholesale infatuation with blanket artificial illumination. The success of contemporary stained glass seems dependent on an acceptance of ornament in general in contemporary architecture and on expressing statements relevant to that architecture.

During the American Renaissance ornament of all sorts was the very stuff which raised the status of a building to respectable architecture. Stained glass was a suitable medium for conveying sought-after connotations of wealth, power, and dignity. Its textured and multi-colored surface fit well with the rest of a busy decor and made it possible to decorate window surfaces as well as walls, ceilings, and floors. With the advent of modernist purism and an aesthetic bent toward more open spaces the material lost its appeal. As a two-dimensional window painting in dim interiors it had no role to play in an

architecture of streamlined efficiency and strip windows. Stained glass had to be cleansed of its function as an easel painting and returned to its rightful function as an architectural art of fenestration and light modulation before it could contribute to the new architecture. The renewed interest since World War II has explored these functions and made studies toward an ornamentation that supports current architectural concerns.

Stained glass is in essence a part of fenestration, the arrangement of windows in a building. Color and brilliance can add much to the quality of light entering a space. Through its graphic structure, whether of metals or concrete, it can greatly affect the character or image of a place. But ultimately, in order to use stained glass most effectively, the architect must be grounded in a full understanding of the role which light plays in architecture. Without the judicious construction of openings in form, the stained glass within them becomes again just a painting in the wall. Natural light has a life of its own expressed in daily and yearly cycles and elaborated in filtering and reflection. Good architecture of any period uses this to best advantage and stained glass is only one elaboration.

As with any topic, the more one explores, the more new questions and possible paths arise. This investigation has not been an airtight historical study but instead has tried to

highlight the major issues confronting architectural stained glass during two very different phases of history. I have purposely avoided discussion of specific materials and techniques as unnecessary to the main issues. There are a number of innovations such as epoxy gluing and structural glass which give new possibilities in our current era. However, the basic issues of light, color/value, and composition remain the same.

Footnotes

Chapter One

1. Brooklyn Museum, The American Renaissance 1876-1917 (New York: The Brooklyn Museum, 1979).

Chapter Two

1. The following discussion was drawn primarily from these sources:
   a. Brooklyn Museum, The American Renaissance 1876-1917.
   b. Charles C. Baldwin, Stanford White (New York: Dodd, Mead and Co., 1931).
   c. Sharon S. Darling, Chicago Ceramics and Glass: An Illustrated History from 1871 to 1933 (Chicago: Chicago Historical Society, 1979).
2. Brooklyn Museum, p. 45.
3. Brooklyn Museum, p. 27.
4. Brooklyn Museum, p. 30.
5. Brooklyn Museum, p. 75.
6. The following discussion was drawn primarily from these sources:
   a. Sharon S. Darling, Chicago Ceramics and Glass.
   b. Robert Koch, Louis C. Tiffany, Rebel in Glass (New York: Crown Publishers, Inc., 1964).
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   e. Barbara H. Weinberg, The Decorative Work of John LaFarge (New York: Garland Publishing, Inc., 1977).
7. Brooklyn Museum, p. 131.

8. Koch, p. 65 and p. 119.
9. Koch, p. 56.
10. Koch, p. 58.
11. Koch, p. 58.
12. Koch, p. 139.
13. Darling, p. 111.
14. Darling, p. 115.
15. Information on Trinity Church was gathered from the following sources:
    a. Henry-Russell Hitchcock, A Guide to Boston Architecture 1637-1954 (New York: Reinhold Publishing Corp., 1954).
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16. Richardson, p. 13.
17. Rice, p. 2
18. Richardson, p. 13.
19. Tucci, p. 47.

20. Richardson, p. 10.

21. Norton, p. 44.

22. Background discussion for this case study was taken primarily from one source: Cambridge Historical Commission, A Survey of Architectural History in Cambridge; Part Four: Old Cambridge (Cambridge, Mass.: Cambridge Historical Commission, 1973). Avon Hill section pp. 50-52.

23. Cambridge Historical Commission, pp. 110-114.

24. Cambridge Historical Commission, p. 114.

Chapter Three

1. Background discussion on the Modernist movement was drawn from the following sources:
   a. Walter Gropius, The New Architecture and the Bauhaus, trans. P. Morton Shand (Cambridge, Mass.: M.I.T. Press, 1965).
   b. Henry-Russell Hitchcock and Philip Johnson, The International Style (New York: W.W. Norton and Co., Inc., 1966).
   c. Jurgen Joedicke, A History of Modern Architecture (New York: Frederick A. Praeger, Inc., 1959).
   d. Nicholas Pevsner, Pioneers of Modern Design (Norwich, Great Britain: Penguin Books, 1960).

2. Pevsner, p. 28.

3. Pevsner, p. 28.

4. Pevsner, p. 30.

5. Kenneth Frederick von Roenn, Jr., "Resurrect Stained Glass as an Architectural Art?" Glass, vol. 7, no. 1 (1979), n. pag.

6. p. 27.

7. Pevsner, p. 37.

8. Gropius, pp. 81-82.
9. Pevsner, pp. 122-26.
10. Pevsner, p. 179.
11. Gropius, p. 29.
12. Arthur Korn, Glass in Modern Architecture (London: Barrie and Rockliffe, 1967), p. 5.
13. Gropius, p. 30.
14. Gropius, p. 33.
15. John Lobell, Between Silence and Light (Boulder, Colo.: Shambhola Publications, Inc., 1979), p. 62.
16. Published in Meaning in Architecture, ed. Charles Jencks and George Baird (New York: George Braziller, Inc., 1970).
17. Norberg-Schulz, p. 216.
18. Pevsner, p. 217.
19. The following discussion is based on von Roenn's article "Resurrect Stained Glass as an Architectural Art?" cited above. Also of interest by him is another article "On Viewing Architectural Art," Stained Glass, vol. 79, no. 2 (1984), pp. 119-23.
20. von Roenn, "Resurrect Stained Glass?" n. pag.
21. von Roenn, "Resurrect Stained Glass?" n. pag.
22. Frank Lloyd Wright, The Future of Architecture (New York: Horizon Press, 1953), p. 323.
23. Frank Lloyd Wright, "In the Cause of Architecture: VI. The Meaning of Materials -- Glass," Architectural Record, vol. 64 (1928), p. 14.
24. Darling, p. 122.
25. Frank Lloyd Wright, "In the Cause of Architecture," Architectural Record, vol. 23 (March 1908), p. 161.

26. Wright, "In the Cause of Architecture" (1928), p. 15.

27. Timothy F. Rub, "Frank Lloyd Wright's Art Glass," Stained Glass, vol. 79, no. 2 (1984), p. 134.

28. Edgar Tafel, "Windows by Frank Lloyd Wright," Stained Glass, vol. 66, no. 2 (1971), p. 20.

29. Lutz Haufschild, "Architectural Stained Glass," Architect's Forum, vol. 3, no. 1 (1983), p. 21.

30. The discussion on Bruno Taut is taken primarily from the following three sources:
    a. John Hix, The Glass House (Cambridge, Mass.: M.I.T. Press, 1974).
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31. From "The Interpretation of the Glass Dream -- Expressionist Architecture and the History of the Crystal Metaphor" by Rosemarie Butler as quoted in Richard's article cited above, p. 115.

32. Richards, p. 114.

33. Hix, pp. 167-68.

34. Information on the Bauhaus work with stained glass was taken from several sources:
    a. Gropius, The New Architecture and the Bauhaus.
    b. Joedicke, A History of Modern Architecture, pp. 67-74.
    c. Hans Wingler, The Bauhaus (Cambridge, Mass.: M.I.T. Press, 1978).

35. Gropius, p. 66.

36. Wingler, p. 330.

37. The following references provided information on LeCorbusier's attitudes toward stained glass:
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    b. Joedicke, A History of Modern Architecture, pp. 87-97.
    c. LeCorbusier, The Chapel at Ronchamps (New York: Frederick A. Praeger, Inc., 1957).
    d. Raymond McGrath and A.C. Frost, Glass in Architecture and Decoration (London: The Architectural Press, 1961).
    e. Stanislaus von Moos, LeCorbusier, Elements of a Synthesis (Cambridge, Mass.: M.I.T. Press, 1979), pp. 252-54.
38. von Moos, p. 254.
39. von Moos, p. 253.
40. McGrath, pp. 309-10.

Chapter Four

1. In clarifying the design aspects of stained glass from an architect's point of view I found the following articles most helpful:
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    b. Travis Thompson, "A Rhapsody of Light: The Resonating Tones of Stained Glass in Tune with Architecture," Architecture Minnesota, vol. 12, no. 1 (1986), pp. 36-39.
    c. von Roenn, "Resurrect Stained Glass as an Architectural Art?"

    The most in-depth analysis was provided by Robert Sowers in three books. He is currently working on a fourth.
    a. The Language of Stained Glass (Forest Grove, Ore.: Timber Press, 1981).
    b. The Lost Art: A Survey of One Thousand Years of Stained Glass (New York: George Wittenborn, Inc., 1954).
    c. Stained Glass, an Architectural Art (New York: Universe Books, Inc., 1965).

2. From Haufschild, p. 21 and Thompson, p. 37.
3. Sowers, The Language of Stained Glass, p. 122.
4. Thompson, p. 37.
5. Sowers, Stained Glass, an Architectural Art, p. 96.
6. Sowers, Stained Glass, an Architectural Art, p. 90.
7. Sowers, The Lost Art, p. 57.
8. Sowers, The Language of Stained Glass, pp. 10-11.
9. Sowers, Stained Glass, an Architectural Art, p. 61.
10. Sowers, The Language of Stained Glass, p. 21 and p. 58.
11. Sowers, The Language of Stained Glass, pp. 15-17.
12. Sowers, The Language of Stained Glass, pp. 86-94.

Chapter Five - none

Illustration Credits

Chapter One - none

Chapter Two

2-1 Robert Koch, Rebel in Glass, p. 94.

2-2 Koch, p. 95.

2-3 Sharon S. Darling, Chicago Ceramics and Glass, p. 113.

2-4 Nicholas Pevsner, Pioneers of Modern Design, p. 97.

2-5 Darling, p. 107.

2-6 James L. Sturm and James Chotas, Stained Glass from Medieval Times to the Present, p. 36.

2-7 Koch, p. 109.

2-8 Koch, p. 109.

2-9 Lara-Vinca Masini, Art Nouveau, p. 286.

2-10 Koch, p. 89.

2-11 Masini, p. 307.

2-12 Darling, p. 118.

2-13 Sturm and Chotas, p. 49.

2-14 Sturm and Chotas, p. 48.

2-15 Henry R. Hitchcock, Richardson and His Times, p. 166.

2-16 The author.

2-17 Hitchcock, p. 166.

2-18 Richard Cheek.

2-19 The author.

2-20 The author.

2-21 The author.

2-22 The author.

2-23 The author.

2-24 The author.

2-25 The author.

2-26 Cambridge Historical Comm., A Survey of Architectural History in Cambridge; Part Four: Old Cambridge, p. 111.

2-27 The author.

2-28 The author.

2-29 The author.

2-30 The author.

2-31 The author.

2-32 The author.

2-33 The author.

2-34 The author.

Chapter Three

3-1 From brochure of the Mies van der Rohe Centennial Exhibition, Museum of Modern Art, New York.

3-2 Pevsner, p. 127.

3-3 Pevsner, p. 139.

3-4 Robert Sowers, The Lost Art, p. 56.

3-5 Walter Gropius, The New Architecture and the Bauhaus, p. 22.

3-6 Gropius, p. 45.

3-7 John Hix, The Glass House, p. 166.

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3-9 David A. Hanks, The Decorative Designs of Frank Lloyd Wright, p. 121.

3-10 Sturm and Chotas, p. 78.

3-11 Sturm and Chotas, p. 77.

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3-13 Darling, p. 124.

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3-15 Dennis Sharp (editor), Glass Architecture/Alpine Architecture, p. 11.

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3-17 Sharp, p. 14.

3-18 Sharp, p. 80.

3-19 Hans Wingler, The Bauhaus, p. 330.

3-20 Wingler, p. 331.

3-21 Sowers, The Lost Art, p. 39.

3-22 Wingler, p. 331.

3-23 Werner Hoffman and Udo Kultermann, Modern Architecture in Color, p. 341.

3-24 Raymond McGrath and A.C. Frost, Glass in Architecture and Decoration, p. 370.

3-25 McGrath, p. 371.

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3-27 Hoffman, p. 343.

3-28 Sowers, The Lost Art, p. 50.

3-29 Sowers, The Lost Art, p. 50.

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4-1 Lutz Haufschild, "Architectural Stained Glass," Architect's Forum, p. 21.

4-2 Sowers, Stained Glass: An Architectural Art, p. 27.

4-3 Otto Rigan, New Glass, p. 113.

4-4 Rigan, p. 84.

4-5 Rigan, p. 52.

4-6 Konrad Pfaff, Ludwig Schaffrath: Stained Glass and Mosaic, p. 99.

4-7 Sowers, The Language of Stained Glass, p. 159.

4-8 Sowers, An Architectural Art, p. 113.

4-9 Sowers, An Architectural Art, p. 113.

4-10 Pfaff, p. 60.

4-11 Pfaff, p. 60.

4-12 Sowers, An Architectural Art, p. 92.

4-13 Sowers, An Architectural Art, p. 60.

4-14 Sowers, An Architectural Art, p. 111.

4-15 Sowers, An Architectural Art, p. 111.

4-16 Sowers, The Lost Art, p. 34.

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4-20 Sowers, The Language of Stained Glass, p. 103.

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4-31 "Light and Form," Canadian Architect, p. 21.

4-32 Wilson S. Snow.

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4-35 The author.

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