WHO WHEN HE FIRST SAW THE SAND AND ASHES BY A CASUAL INTENSENESS OF HEAT MELTED INTO A METALLINE FORM, RUGGED WITH EXCRESCENSES AND CLOUDED WITH IMPURITIES, WOULD HAVE IMAGINED THAT IN THIS SHAPELESS FORM LAY CONCEALED SO MANY CONVENIENCES OF LIFE AS WOULD, IN TIME, CONSTITUTE A GREAT PART OF THE HAPPINESS OF THE WORLD. YET BY SOME SUCH FORTUITOUS LIQUEFACTION WAS MANKIND TAUGHT TO PROCURE A BODY AT ONCE IN A HIGH DEGREE SOLID AND TRANSPARENT; WHICH MIGHT EXTENT THE SIGHT OF THE PHILOSOPHER TO NEW RANGES OF EXISTENCE, AND CHARM HIM AT ONE TIME WITH THE UNBOUNDED EXTENT OF MATERIAL CREATION, AND AT ANOTHER WITH THE ENDLESS SUBORDINATION OF ANIMAL LIFE; AND, WHAT IS OF YET MORE IMPORTANCE, MIGHT SUPPLY THE DECAYS OF NATURE, AND SUCCOUR OLD AGE WITH SUBSIDIARY SIGHT. THUS WAS THE FIRST ARTIFICER IN GLASS EMPLOYED, THOUGH WITHOUT THIS KNOWLEDGE OF EXPECTATION. HE WAS FACILITATING AND PROLONGING THE ENJOYMENT OF LIGHT, ENLARGING THE AVENUES OF SCIENCE, AND CONFERRING THE HIGHEST AND MOST LASTING PLEASURES; HE WAS ENABLING THE STUDENT TO CONTEMPLATE NATURE, AND THE BEAUTY TO BEHOLD HERSELF.

DR. SAMUEL JOHNSON

he things that I thought yesterday I no longer feel. New "truths" have presented themselves, making great principles of six months ago ridiculous. Perhaps I am young, and some day will come to a true understanding; perhaps I will always search and never find a base upon which to build. hanges must be motivated by intellect. "Intellect is the tool of imagination -

it creates nothing - the eye sees - the ear hears - imagination perceives, conceives, creates", says Frank Lloyd Wright. Perhaps that is true today, but even that, tomorrow, may be false. One might easily capitulate, but perhaps it is best for truths to last only a short time, and in so doing give way to a new way of thinking. Perhaps that is progress. In this work I will try to set down some things which seem to me to be important. But I know tomorrow I will scoff at them, and today most people will. In our age changes are occurring, which are the most important since the first true Gothic structures, but time may tell differently. This change has been called the first self-conscious assertion of building in the third dimension. Architecture is not four walls and a roof, all proportioned well with ornament applied but space enclosed, that space being as flexible and well suited to the purpose for which it was intended as is possible. Glass is playing an important role in our desire for the control of space. We reverence the sun as the Aztecs, and fresh air is our god. Fusing the outdoors and indoors is best done with this versatile material. This "tying together" or "organic building" is greatly brought about by the increased use of the material which has made architectural history, by its scarceness and size of sheets

available. Corbusier says, "the history of architecture is the struggle for the window". After two thousand years glass is manufactured in sheets up to 250 square feet and is cheap. But how shall we handle it? Frank Lloyd Wright has written: "Shadows were the 'brush-work' of the ancient architect. Let the 'modern' now work with light, light diffused, light reflected, light refracted - light for its own sake, shadows gratuitous. It is the Machine that makes modern these rare new opportunities in Glass - new experience that architects so recent as the great Italian forebears, plucked even of their shrouds, frowning upon our 'Renaissance', would have considered magical. They would have thrown down their tools with the despair of the true architect. They would have transformed their cabinets into a realm, their halls into bewildering vistas and avenues of light - their modest units into unlimited wealth of color patterns and delicate forms, rivalling the frostwork upon the window panes. The Prism has always fascinated man. We may now live in prismatic buildings, clean, beautiful, and new. Here is one clear material proof of modern advantage, for glass is uncompromisingly modern. Yes- architecture is soon to live anew because of glass and steel." n the following pages I shall try to give a brief accurate account of the effect glass has had

upon the cultures of past generations, followed by some ideas regarding the best expressions of glass in our design of today, with a study of the technical limitations of glass now. Photographs that show best the effect of glass upon our architecture of today will conclude this thesis. It is my contention that no work, no matter how little or big it may be, is of any worth to anyone unless it is exciting and fun to the worker. It is with this attitude that I wish always to work, and although it is unlikely that the pleasure that goes in doing it will accord for its shortcomings.

GLASS IN ARCHITECTURE AND DECORATION
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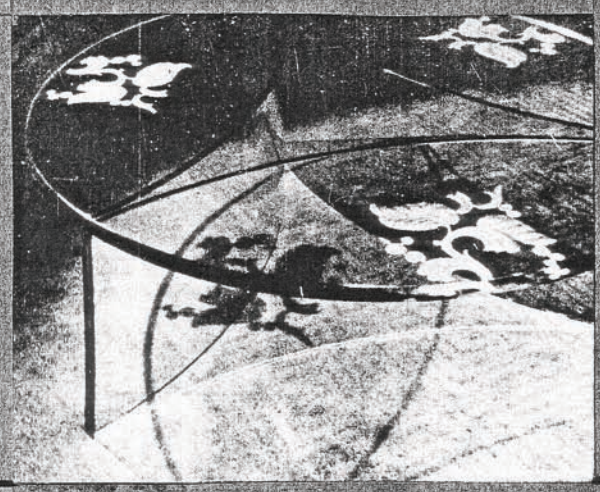
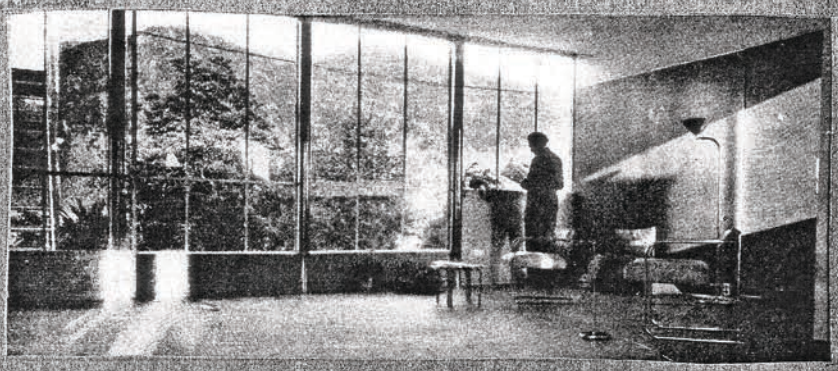
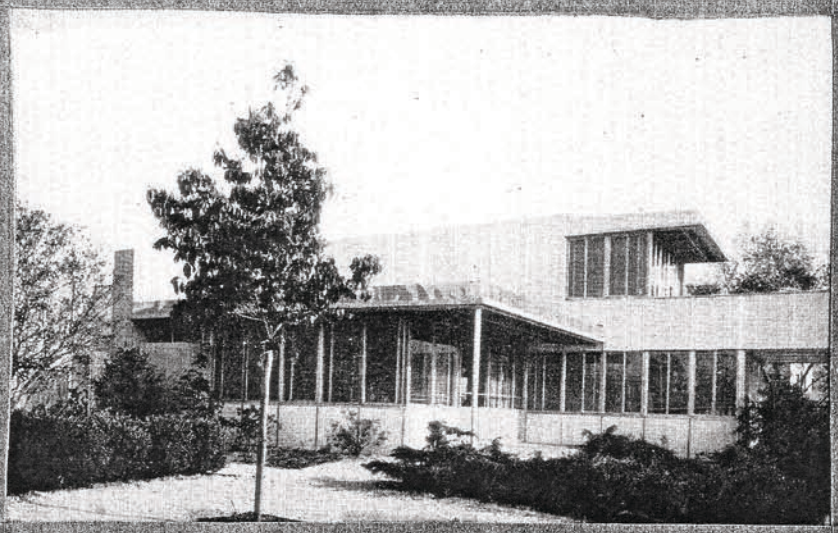
Photographs

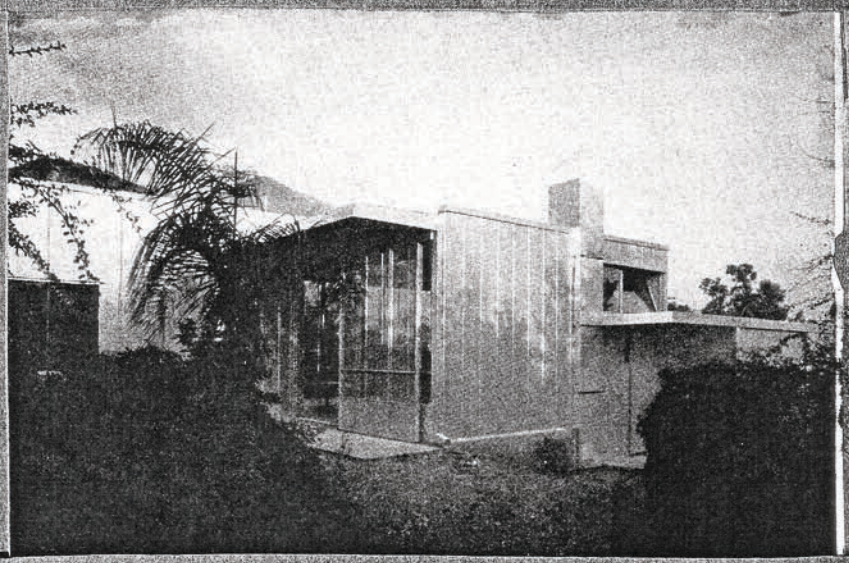
In the glass wall at Rockefeller Center the sculptured planes scatter and redirect the light rays filling the entrance hall with an abundance of light even on dull days. Thus the functional tradition in glass is continued in one of the most important glass-in-architecture installations in modern times. The pressed glass screen measures 55 feet wide and 15 feet high. 240 rectangular blocks, each 18" by 28" form the wall. The thickness varies from $4\frac{1}{2}$" to $1\frac{1}{2}$".



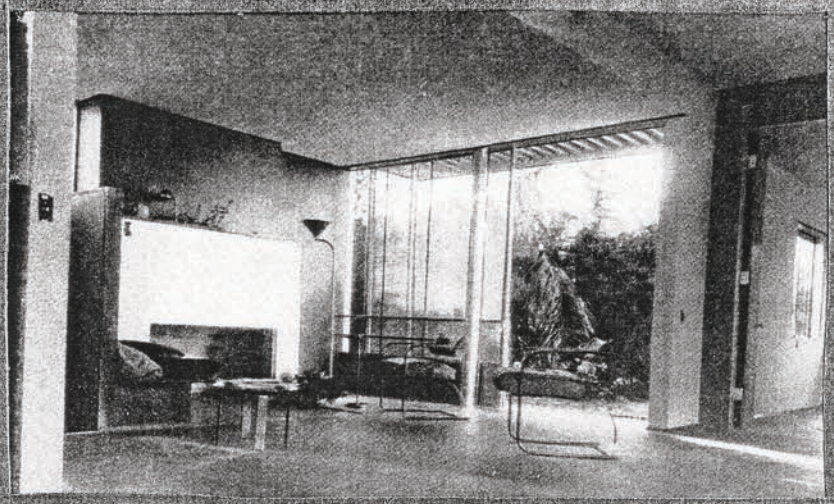
Top....A ceiling panel by Paule and Max Ingranck representing the three muses of entertainment. It is executed in sandblast and acid-embossing on gold leafed plate....Middle....An example of modern leaded glass work....Bottom.... A piece of furniture which is decorative

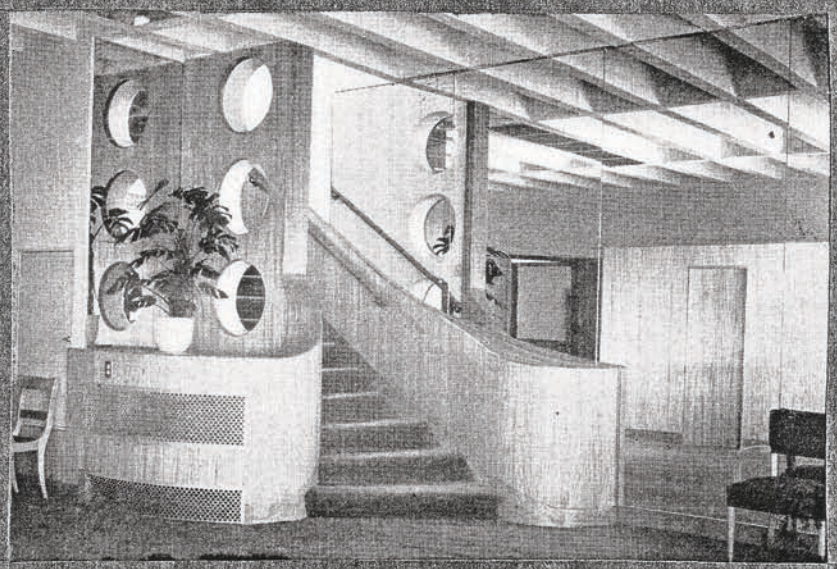




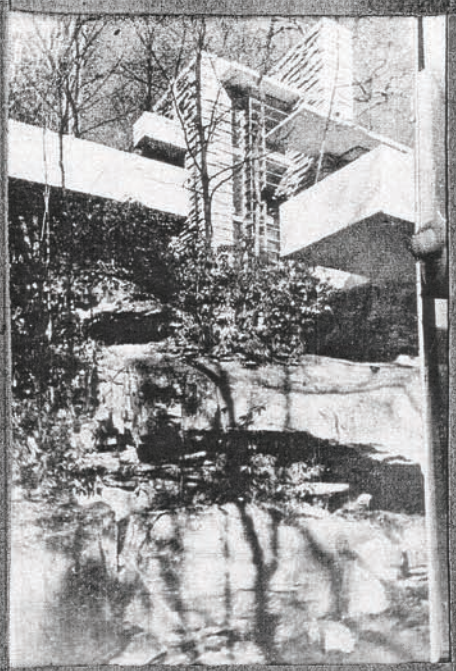


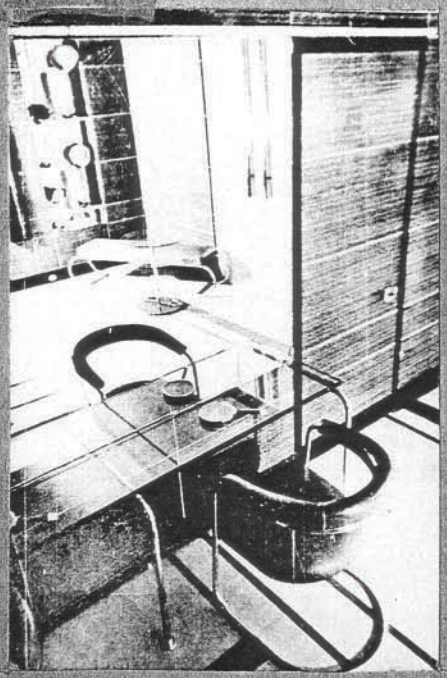
"The new materials and structural methods available today permit, when used unadulterated, a natural and more intimate relation to the out-of-doors and a consequent full benefit of its health factors," says Mr. Neutra, examples of whose work are shown above.

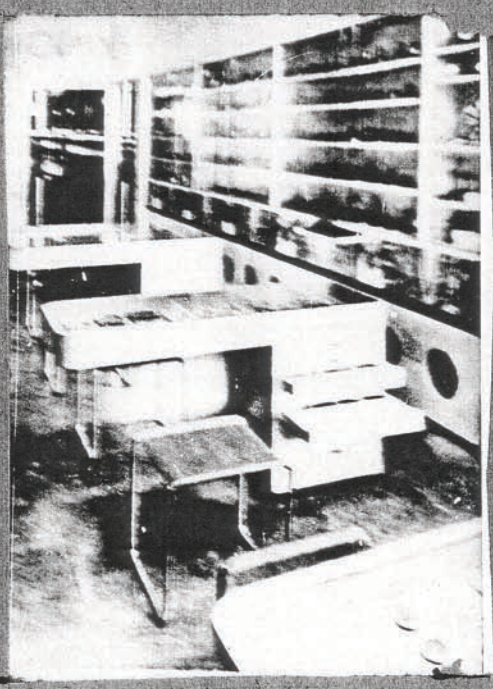




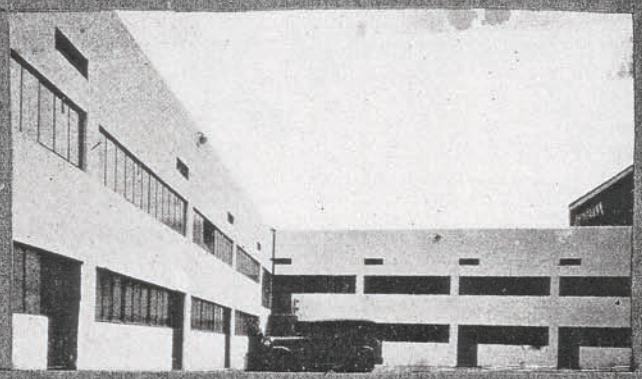
Top....Neutra uses glass intelligently....Middle... Mirrors in a commercial establishment....Bottom.... "Lairea", a house in Normark which takes advantage



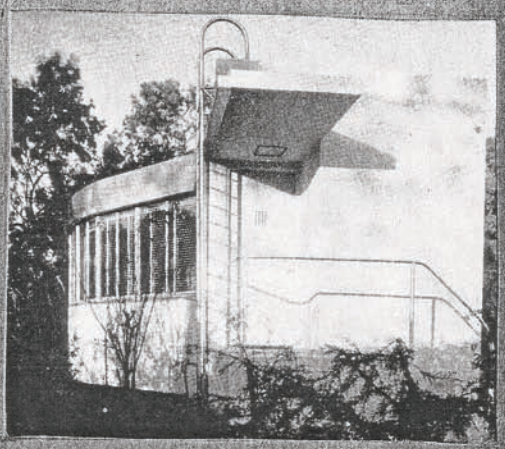


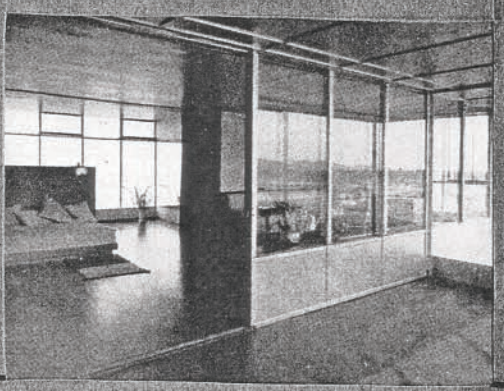


Top left....Here, a void is used to accent a vertical with much success, although such a treatment is seldom successful....Bottom left....The walls of this interesting residence consist almost entirely of sliding and movable doors alternating glazed with clear and frosted light.... Top and bottom right....Glass at its best in commercial furniture.



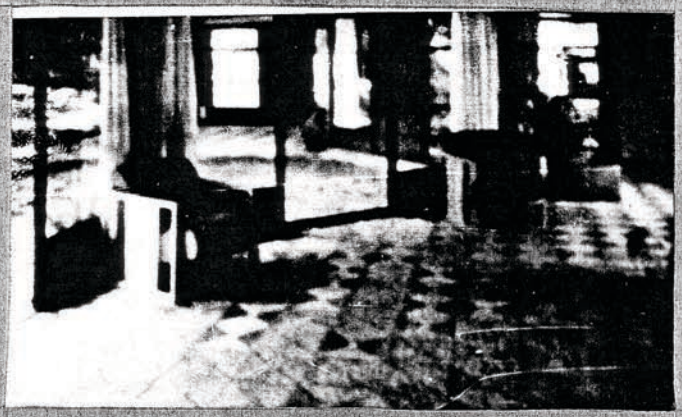
Wide spans, slender supports, liberal openings are at last possible. Mankind has always secretly wished this.

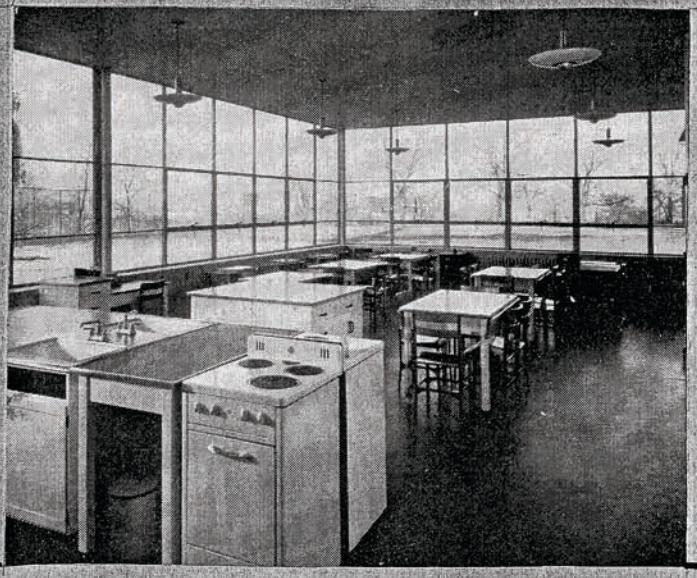




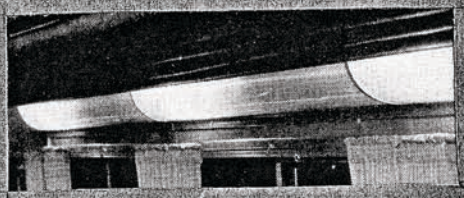
Neutra controls and shapes

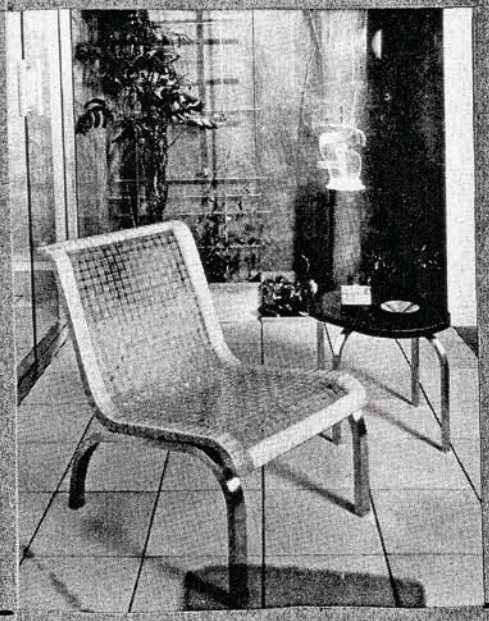
his glass areas with the hands



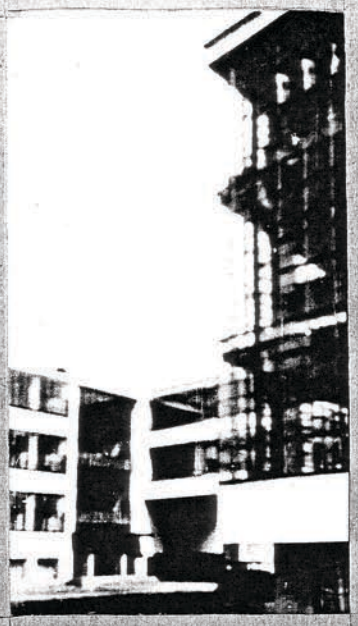


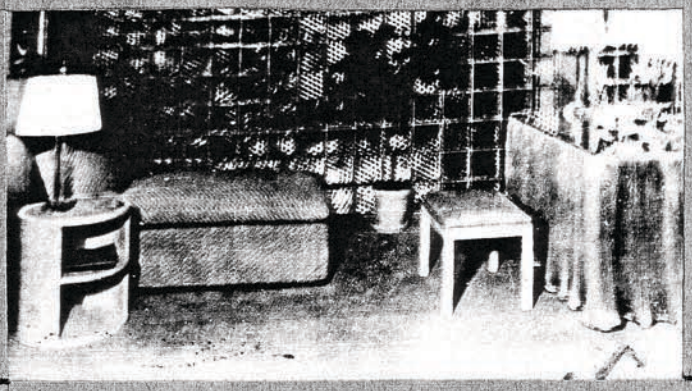
Top....The terrace is an extension of the living room....Middle....Glass as can be used in a school shop....Bottom....Glass as used in a home economics laboratory.



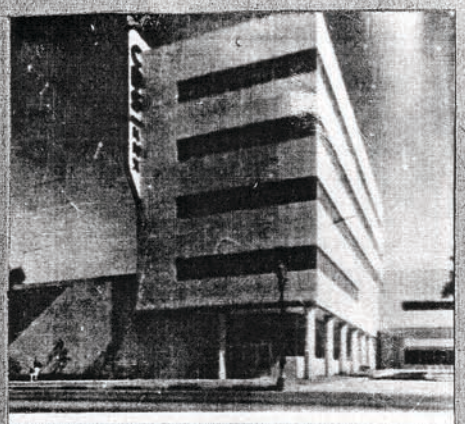


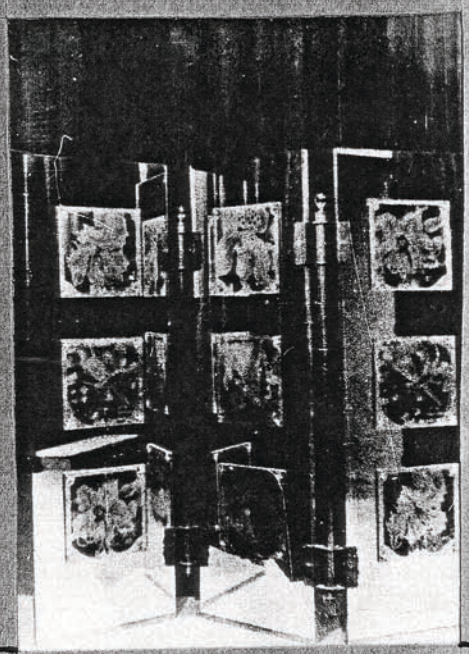
Top left....Bent "Lucite" sheet used in lighting fixture....Top right.... Extruded, elastic "Vinylite" strips woven for chair seat and back....Bottom left.... Sign, demonstrating "edge lighting"....Bottom right.... Extruded "Lumarith" chair with "Plexiglas sculpture in background.



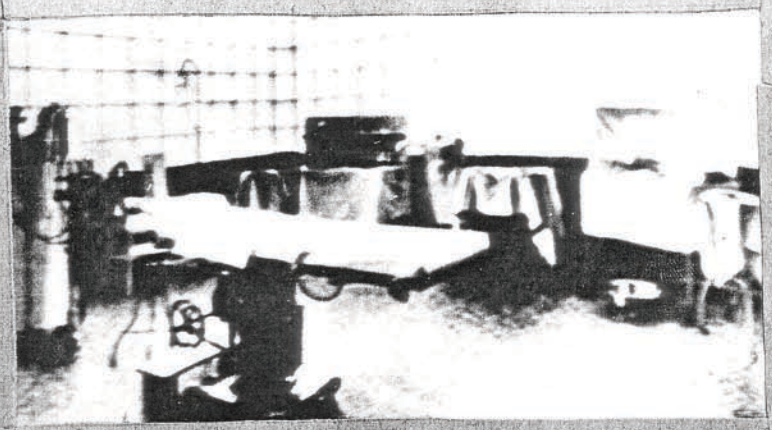


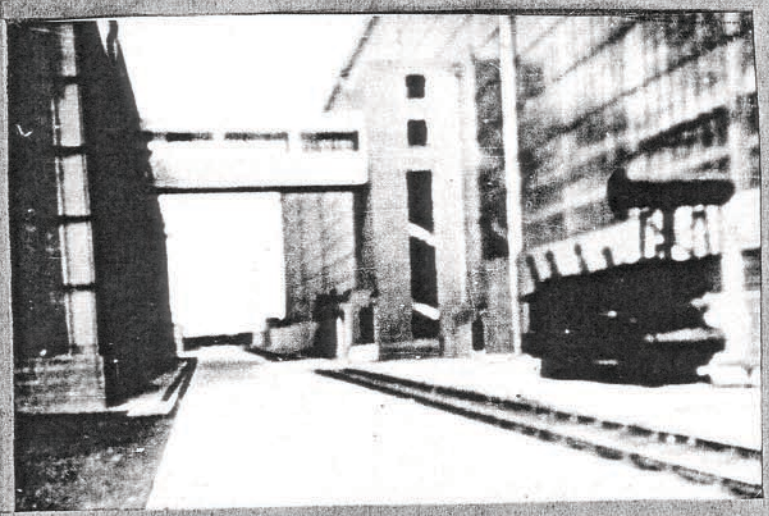
Top left....Walter Gropius(famous school ....Top right....A ceiling panel in the hall of a private house, "La Voie Lactee". The design is sandblasted on gilt mirror so that the forms are translucent.... Bottom....Glass brick should always be used as a masonry material.

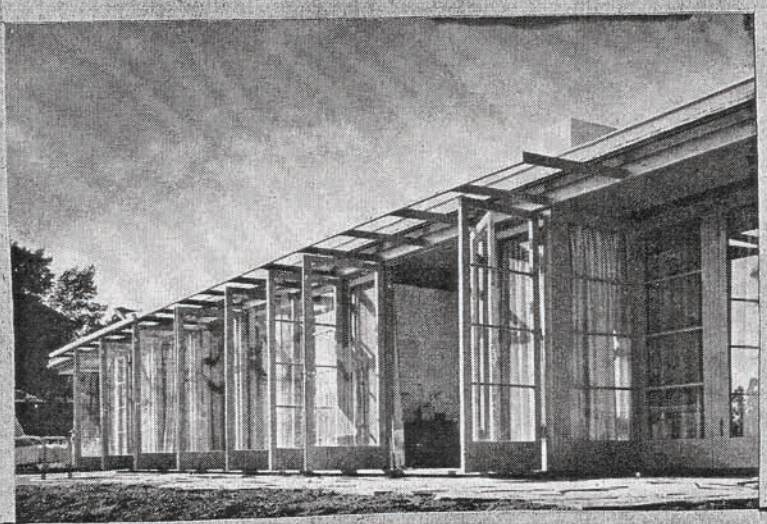




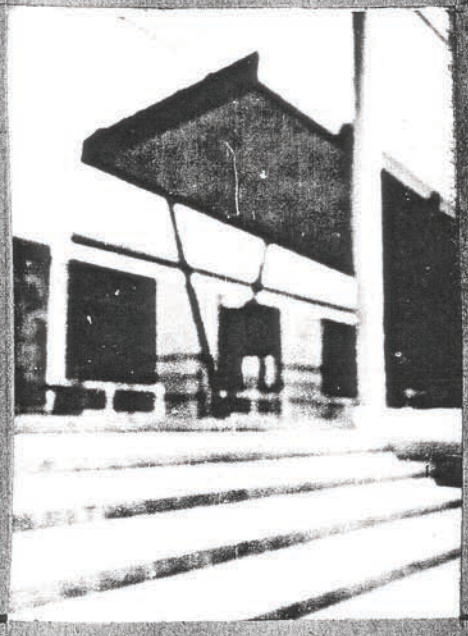
Top....Horizontal bands of light have been exploited in recent years....Bottom.... This mirrored screen has panels, which are slightly raised and executed in sand-blast on the back of the glass and colored with brown

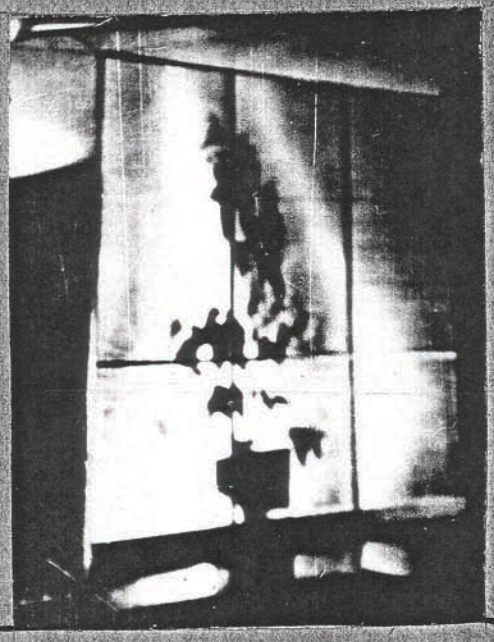




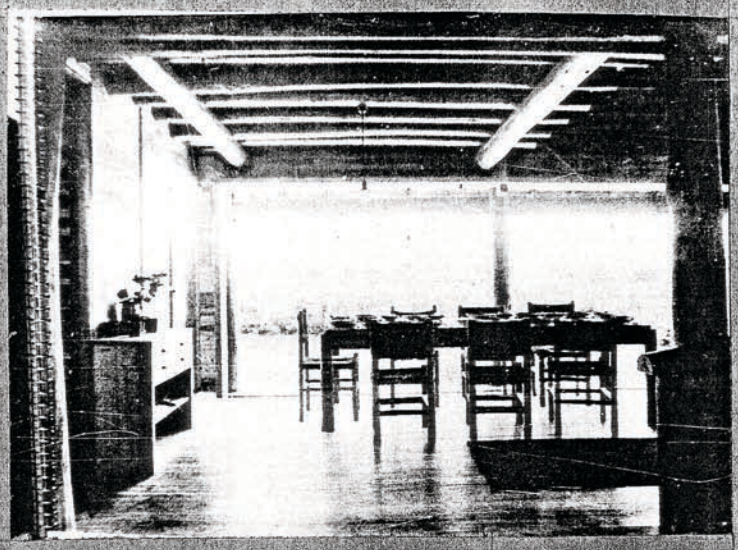


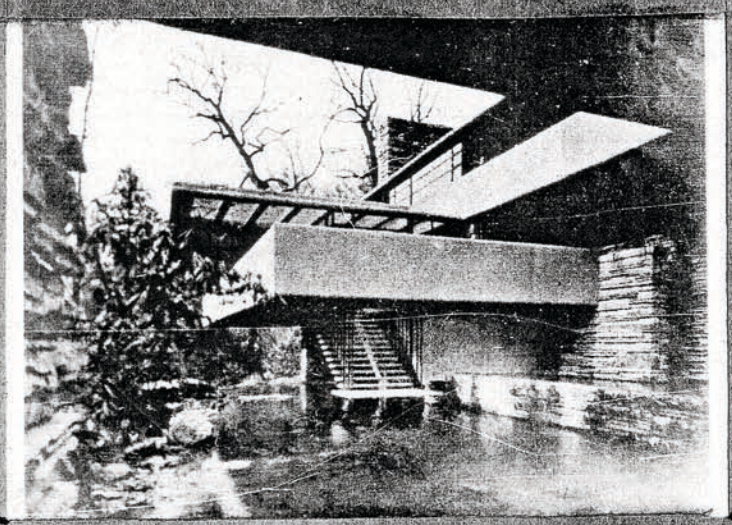
Top....Glass block used in a hospital operating room....Middle....Glass in large areas is accepted for factory buildings....Bottom....For residence the layman is not so sure.





Top left....Glass as used in a very impressive interior.... Bottom left....Cité de Refuge, is airy and very colorful because of its glass....Top right....A decorative panel of moulded glass....Bottom right....A decorative screen of translucent glass. The plant behind gives a very interesting effect.





Top and Middle ... The walls are here made up of flexible glass partitions, with a fine feeling of support.... Bottom .... A glazed exterior skylight of Wright's.

Outline

Historical sketch

- Origin
- Roman and Venetian glassmaking
- Gothic windows
- Renaissance
- The Crystal Palace

Glass and its relationship to modern architecture

- The glass wall
- Comparison of window sizes
- Opaque glass
- Glass block
- Translucent glass

Glass and decoration

- As an integrally decorative material
- Mosaics
- Vitroflex
- Stained glass
- Mirrors
- Methods of treating glass

Limitations of glass

- Size
- Heat and sound losses
- Strength

There are many tales as to how glass was discovered, that most legitimate being that related by C. Pliny in his "History of the World". He recalls that there was a river in Phoenicus named Belus whose waters were muddy and unwholesome and nothing was to be found on its banks but sand. One day traders sought some stones on which to mount a tripod to cook their food. Being unable to find anything they could use they took some blocks of nitre from their cargo. Under the heat of the fire, the sand coming into contact with nitre, which acted as a flux, formed a vitreous substance - "glass".

Syria is without doubt the seat of its origin. There was frequent intercourse between Syria and Egypt, and it is significant that the glass factory discovered by Sir Flinders Petrie at Tel-el-Amara dates from 1,400 B. C. immediately following the Egyptian conquest of Syria. Besides the evidence of a sculptured record dating from this time and representing Syrian workmen being brought into Egypt carrying vessels of metal or glass, there is no record of glass making as an industry prior to this time.

The blowing of glass was probably invented about the time of Alexander. It was a remarkably ingenious invention for it takes about 500° Centigrade of temperature to get the metal into a sufficiently liquid form to blow. Glass blowing found its way to Egypt from Syria. Glass blowing was naturally applied to bottles, and vessels of every description. The Alexandrians shared the industry with Syria in the centuries immediately following; the Syrians supplying most of the free blown work, while the Alexandrians did most of the moulded, cut and generally decorative work.

Glassmaking in Rome was started when Egypt became a province of the Roman Empire. Egyptian workmen, as well as enterprising Syrians, caused the manufacture of glass early established in Rome itself. Though their development of window glass seems to us to be unaccountably slow, their application of it to domestic purposes, architectural decoration, and personal ornament reveals the most thorough comprehension of its possibilities in these directions.

The climate of the Roman Empire presented no special necessity for glass in their windows. Earliest

window was probably a modification of the doorway. It is interesting to note that light was generally received from above and lateral penetration was unusual. The Cretan palaces at Knossos and Phaestos, besides being lighted by mullioned windows, surprisingly modern in appearance, had openings or shafts at the end of the hall by means of which the hall and corridors and stairs were lighted. That these were open to the stairs is indicated by the fact that the floor below is slightly sloping and often connected with a drain.

Methods of making window glass in Roman times varies greatly from our present methods. The metal was poured onto a plate and then drawn with pincers, the marks of which may still be seen. It was not even on both sides because of the sand with which the plate was spread before proceeding with the casting. The largest known plate was three feet and eight inches by two feet eight inches used in the public baths at Pompeii. Wherever the Romans went they introduced glass and its manufacture, and it lasted through the Middle Ages.

The Romans used glass in many ways although it was used very little in window. Marvellous examples of technical skill are shown in the Portland vase, the market

for onyx glass of this sort, murrine glass and so on being supplied by the Alexandrians. Horace makes mention of pictures painted on glass with which he decorated his room. St. Pauli near Rome, built by Constantine about 337 had glass "of various colours as brilliant as the field of flowers in the spring". It was used other than decoratively as is brought out in Columella's advise, "if you want cucumbers you must put them during winter under glass exposed to the sun". By 220 the manufacture of glass had assumed such proportions that Alexander Severus laid a tax on Roman glassmakers.

Owing to the impurity of the raw material and the crude method of manufacturing, the glass of Roman times was not the bright clear transparent substance that we know today. St. Paul refers to this when he says: "For now we see through a glass, darkly"-I Cor., XIII.

The Venetian glass industry has received much historical emphasis owing to the excellent form, quality, and workmanship of their glass. The Venetians exhibited the typical clannishness of the glassmaking fraternity and at an early date consolidated their craft as a "mystery", forming themselves into a guild which provided severe penalties for any devulgence of their

secrets. This closeness concerning their trade was typical of all glassmakers until quite recently. The reason for this secrecy lay in the difficulties of glass making, for it took three generations to make a master, hence there was a strong family tradition. There was no scientific knowledge so the rule-of-the-thumb formulas had to be handed from father to son. Although they made beads, glass vessels, spectacle lenses, ships' lanterns, and some window glass, their chief contribution was the mirror, which they coated with an amalgam of tin and mercury.

Civilization's spread to the north hastened wide use of glass in windows. Of course, only the more important structures made use of glass at first. In the early churches at S. Martino and the Quattro Santi Incoronati at Rome, for example, the windows were closed with thin slabs of marble, though in some basilicas these slabs were pierced in the orinetal manner to receive some glass, which may or may not be coloured.

The decorative use of glass in medieval churches arose from its capacity for taking colour, either during manufacturing or afterwards by painting the surface with vitrifiable colour and burning it. The earliest

Christian mosaics still surviving are probably those at S. Costanza. From the use of glass as a mosaic, it was a short step to its use in windows with a mosaic effect.

The Seine-Rhine area is outstanding for its contribution of window glass. The large and increasing ecclesiastic demand caused two methods of producing sheets of glass to be developed: the cylinder method, and the crown method.

Painted glass was used in the eleventh century quite extensively for pictorial decoration, although we have little actual remains of it until the thirteenth century. In Romanesque churches the decoration consisted mostly of frescoes and mosaics, but the development of the Gothic, which presented narrow spaces unfavorable to mural painting, led to the decoration being applied to the window which had greatly increased in size.

Coated glass was used from the thirteenth century on, it being red glass coated or cased with a layer of white. Certain parts of the red glass were taken away to uncover the white, and so a design was made. It was not long until various coloured glass was introduced into the white parts. By the middle of the fifteenth century the development in the art of glassmaking had become

sufficiently studied that it was possible to get almost anything they wanted. The increased knowledge of chemistry had enabled them to paint upon a single piece of white glass, using the glass only subservient to the painter as a canvas in oil painting. The use of silver nitrate, which produced a silvery yellow stain, was discovered and made use of quite frequently. It finally became so popular that whole windows were done in it; a simple stoke on white glass sufficing for the outline "grisaille" for shadows.

As the Gothic windows became larger a great proportion of white and yellow stained glass was introduced, and the colors became much less intense in hue. The richest colouring known in painted glass occurs in early English picture windows, when the white has a strong green tint, deep blues and reds predominating, the flesh tints are deep, and the whole is simple and grave. "There is no doubt that the earlier method whereby the light was either intercepted by masses of rich colour or concentrated in small spots of white made for a more diamatic and decorative effect and one which was more appropriate to the fervor and gaiety of medieval Christianity." (Glass in Architecture and Decoration by Raymond, McGarth, and Frost) The glass was far from being free of such inprojections as air bubbles, and even small pieces of solid matter. The surface was generally

uneven, causing the light that fell on it to be scattered and refracted, making the glass almost self-luminous.

Gothic architecture depends upon glass. The conception of a building being made up of an enclosing wall pierced with holes for light, and with a roof resting on it was alright for many an ancient building, but in the Gothic this gave way to piers from which branched the ribs of the vaults; the window's spread becoming little more than a curtain ".....a stone cage with films of stained glass suspended in the voids, a marvellous jewelled lantern". (Lethaby)

Gerhard Rosenberg in the A. I. B. A. Journal for January 18, 1936, wrote: "Ordered liberty rules the formation of the windows of the Gothic cathedral. With the invention of glass, windows could be enlarged without fear of the rain and wind; and as the glass could not be made clear, it consequently was preferred coloured rather than in colourless obscurity and the amount of light was greatly diminished. It determined the size of the windows. There was no reason to keep any solid wall between the piers; therefore, the whole panel between the piers could be turned into a window. The reveals of these windows, splayed in plan for better

spreading of light, were moulded to keep the rain off the surface of the window with its many lead joints, which were particularly endangered by driving rain. The pointed vault of the nave was logically taken up by the pointed arch of the window, which came as close to the underside of the vault as the reveal allowed; the latter naturally continued round the arch. Panes were made in size not much over eight inches square, lead glazed panels had to be no larger than two feet six inches square if they were to be rigid. This made the introduction of stone mullions necessary and determined their distances within very narrow limits."

Limited size of glass did not handicap the Gothic architect, therefore, there was not too much incentive to increase the size of glass. The architect made the lead lines part of the design, hence gaining one of his most subtle and important effects. Much of the beauty of a Gothic window is the textured surface of its great windows.

Domestic buildings were without glass for some while, even though glass was used rather widely in church buildings. In the time of Henry III we have a record of his giving orders for the making of windows for his painted chamber at Winchester, "which is too dark", and at Clarendon where the windows were to be "cleft through the middle

that they may be shut or opened when necessary", the great hall at Northhampton was to have "the windows on the north side glazed with white light", and the queen's wardrobe at Westminster a glazed window "so that the chamber may not be so windy as it used to be".

There is no reason to believe that glass was everywhere believed to be the perfect window material for we find records of the use of lattices being praised, as well as "fine linen cloth dipped in oil amber". However, by the end of the sixteenth century, glass ceased to be a luxury and came within the reach of all but the poor.

The Tudor window was encouraged because of its adaptability and the increasing supply of glass. A small unit of glass was used and by placing these side by side or one above another, either vertical or horizontal windows were formed. The very elaborate fenestration of the large Elizabethan houses is obtained thus. Fine examples are Kirby Hall, Northampton or Ostley Hall, Lancashire. "The peculiarly intimate feeling of Tudor architecture with its patterned treatment, its brick-work, and ornamental plaster, and half-timbering, demanded exactly such a window as this."

The arrival of the Renaissance style had a considerable effect on glass and led to an adaption of the mullion to classical design and later the sash in the seventeenth century. The sash developed naturally and independently in various countries from the sliding casement in which two frames slid in parallel grooves, overlapping and caught at a single vertical bar. The manufacturing of glass had progressed sufficiently by 1685 to provide the Banqueting Hall with sash windows whose panes were thirteen by ten inches. Crown glass was used almost entirely and helped to give a distinctive appearance to the windows, because of its slight curvature of the panes and the great diversity in tone ranging from purple to green and sometimes iridescence. This is due to the high proportion of soda, which lead to rapid discoloring. The size of the glass was varied according to the size and importance of the room, as well as the variety of emphasis on the different stories give more interest to the building as a whole.

The sash window and crown glass predominate together throughout the eighteenth century. It was a period of perfection rather than innovation. Sash windows were so popular that oftentimes fine casements were stripped from houses and sash windows installed.

Georgian and Palladian styles were developed during this time necessitating very formal and symmetrical arrangements.

The Palladian window had very definite rules to govern the size and number of panes. When the style was erased in England it often resulted in too small a window to suit the climate although this offset somewhat by the use of a large architrave. The considerations of facade that preoccupied the English Palladians along with their strict observance of the various canons prevented any ultimate adaption of it to English convenience.

The Georgians were parallel with the alien architecture of the Palladians. It developed freely and vigorously and died hard if it can be said to have died at all. Here too the normal window was the sash, though the mullion and transom was still to be found and the casement was still in the upper stories. The early sash was heavily framed and had glazing bars two inches wide and was even occasionally filled with separate lead lights each containing four rectangular quarries. These heavy margins gave a very sturdy feeling, but were structurally unnecessary, and during the following century were gradually refined until by the Regency period the bars were reduced to one-half an inch.

The gradual change of the bars did much to relieve the feeling that the window was divided into bayles, but this feeling could not be eliminated altogether. Cleaning the windows was a nightmare and many hundreds have lost their lives because of the hazards of just this thing.

The sash must be looked upon as a compromise between the larger window opening demanded by the Renaissance and classical style and the heavy framework necessary to support the assemblage of relatively small panes supplied by the glass industry at that stage of its development. So long as the window was not expected to open and close its size was merely limited by structural needs, but once it was required for ventilation an entirely new set of qualifications arose. Style demanded an upright aperture, the available glass a comparatively heavy frame and ventilation a method of opening which would put an undue strain on the heavy frame and which would also permit of modification according to the weather. The result was the sash and the awkward horizontal bar the condition." Glass in Architecture and Decoration - Raymond, McGarth and Frost.

The "Croise" window responsible for much of the charm of French architecture. It is a window in which the transom was placed above eye level and doors hinged and meeting

at the center. This character of the door caused it to be used in connection with balconys and terraces. Lowered shutters permitted the window to be fully opened and at the same time the strong glass of the sunlight was masked. It was far superior to the sash in artistic effect as well as function.

The bay window came into being about the middle of the eighteenth century and much time was spent exploiting the possibilities of curved and semi-hexagonal bay arrangements and adapting it to classical design. The most important consideration, however, is not the design but the choice of outlook. The room "with a view" was perfected at this period, especially in the palatial houses. "The contemplative use of the window meant a high stage of culture; it meant that man originally built his house in order to shelter or separate himself from the universe, now opens it out to look again upon nature from quite a new point of view, to find harmony and a new course of strength where originally there had been conflict and fear. In the history of architecture the emphasis of the window for this purpose was noticeable at several periods. The high culture of the educated classes in the Roman world is well established and is well illustrated in a single sentence from Pliny's letter

to Gallus describing his Laurentine villa: 'A little set-back on the left is a roomy bedroom, then a smaller one with one window to let in the dawn, another to hold the sunset; with a view too of the sea below-farther off, certainly, but safe." The Middle Ages saw the obliteration of this point of view in the reversion to a more primitive attitude to nature. Contemplation then meant inward contemplation; and, in a more practical aspect, the medieval window did not permit of either embracing or an undistorted view of the external world. To enjoy a prospect from a window two things are necessary: just the leisurely appreciation of nature and an unobstructed opening or clear, colourless glazing." (Theory and Elements of Architecture - Atkinson and Eagenal)

The seventeenth century saw the perfection of the garden as a place that provided both a setting for the house and an opportunity for design unthought of before. The medieval castle, of course, had its walled-in garden and in the sixteenth century in Italy the villa was designed as the focus of formal gardens decorated with statues and fountains, but it was not until the seventeenth century that the intimacy of gardens was widely appreciated.

The enthusiasm of the garden was felt in the increased desire to force the growth of fruits. The greenhouse

had been anticipated in the time of the Romans, for Pliny mentioned that Tiberius had cucumbers forced in his garden by means of enclosed stoves. At first the greenhouse was distinguished in front from an ordinary house by the possession of larger windows, and an opaque roof. It was used for entertainment as well and took the place of Summer and Banquetting-houses; The Hampton Court built for Queen Anne, was intended equally as winter garden and the Queen often used it for her summer suppers. Gradually it was realized that there would be great advantages to a glass roof as well as wall and so the greenhouse became much more functional.

When window roofs were introduced, numerous difficulties faced the gardener who previously had merely adapted ordinary windows to his sashes. The angle of the roof increased the danger from hailstorms and glass replacement became quite a problem. Plants were being scorched, too, which added to the worries of the times. The uneven surface of sheet glass was found to be the direct cause of the scorching, the "cockles" forming lenses of considerable power. Experiments were made with Hartley's rolled plate, whose irregular ribbed surface diffused the light and prevented any harmful concentration and also eliminated the need for shading

in hot weather. Sheet glass has been improved today until there is no economic rival today.

The general ignoring of glass in anything but its "accessory capacity" leads us to overlook the significance of its use in the Crystal Palace, but in 1851 glass was by no means taken so much for granted as it is now. Joseph Paxton, the designer and builder, "partly because of his freedom from academicism, but chiefly because of his instinct for practical essentials, evoked a building that was in the highest degree homogeneous physically and functionally". (Glass in Architecture and Decoration by Raymond, McCarth and Frost). The glass used in the roof of his great work was sheet glass, blown in cylinders providing three strips or pans ten inches wide. The huge glass covered transcepts were 72 feet by 48 feet and 68 feet high at the highest point. There were various arrangements of galleries, aisles and entrances, all of which were covered with glass. The roof was built in ridges and furrows, which allowed the sun to come in normal in the early morning and late afternoon, but at an oblique angle at noon. After its re-erection at Sydenham, the Crystal Palance underwent marked neglect. Just exactly what it was like in May, 1851, is a matter for the imagination, but nevertheless the Crystal Palace

compared advantageiously with an exhibition building of the twentieth century. "The touch of poetry revealed in the christening of an exhibition building as the Crystal Palace was surely a popular indication of the fact that mechanization does not invariably mean the emphasis of the unromantic. (Glass in Architecture and Decoration - Raymon, McGarth and Frost). "The Sydenham palace is what it pretends to be. It asserts loudly that it is glass and iron- and it is glass and iron, and everyone can see through it ...It shows the dull sky when it is dull, just as it shows the blood-red flushings of its summer sunsets, when every pane turns ruby as if vintage had been held upon the roof and the flowing grape-floods had dyed it. Thus, also, it has a poetry of its own-the poetry of fact and of nature, rather than of fantasy. It is the poetical product of a materialistic age-it is a realized idealism worked out in a century of reality- it is fiction grown into fact, with a tinge of its old fabulous poetry about it."

The significance of the Crystal Palace cannot be over-estimated. The architectural qualities are those which many modern architects are deliberately attempting to achieve in their designs, often rather by the elimination of non-essentials than by positive planning. It was perhaps the first expression in architecture of

mechanization, and was certainly the first example of prefabrication. The principles evolved by Paxton were not allowed to develop freely and logically; however, due largely to the misguidance of John Ruskin. There is little doubt that Paxton was in advance of his times, which is further shown by his proposed Great Victorian Way for London which was fortunately never carried out. The great activity in the building of conservatories and winter gardens that characterized the nineteenth century produced, as might be expected, varied results. They gave a tremendous impetus to the construction of glass and iron structures in many fields. "When twentieth century architecture comes to be estimated and elucidated by a not impossibly enlightened posterity it may well be that we shall find our buildings fathered onto a greenhouse. It may be that our posterity will see less to laugh at in this than we should." (Glass in Architecture and Decoration by Raymond, McGarth and Frost)

The Crystal Palace was a pioneer in a great new movement. Walter Gropius, in his book, The New Architecture and the Banham, said "Our great technical resources have furthered the disintegration of solid masses of masonry into slender piers, with consequent far-reaching economies in bulk, space, weight and haulage. New synthetic substances - steel, concrete, glass - are actively

superseding the traditional raw material of construction. Their rigidity and molecular density have made it possible to erect wide-spanned and all but transparent structures, for which the skill of previous ages was manifestly inadequate. This enormous saving in structural volume was an architectural revolution in itself". Paxton was the major pioneer of this modern movement and his Crystal Palace the first landmark.

Enthusiam for glass produced many works following the Great Exhibition and in huge quantities, despite the academic architects who felt that at best glass was an unsympathetic material. Of course, it had to pay for its novelty by being used poorly, and in poor taste.

Glass was the answer to the shopkeeper need for exhibiting his wares safely and attractively, and consequently he started using it in enormous proportions. The use of large plates of glass demanded an entirely different treatment, and throughout the nineteenth century this treatment was so inadequate and crude, especially in conjunction with elaborate mouldings of heavy masonry, that it seemed until the last few years that the shop front would never be in good taste.

In the old days the shops existed for the public; the modern view, tacitly accepted by the public, is that the public exists for the shops-as shop fodder-at the present we get the shops we deserve, but it is incredible that society will tolerate indefinitely that juffling with the laws of supply and demand, at the expense of both producer and consumer, which, under such highsounding names as "merchandising" and "salesmanship" has superseded the respectable business of distribution." (Modern English Architecture-Charles Marriott). There is not doubt that shops need to be redesigned, upon an entirely different basis, appealing to the public and making it easier to get the article that you wish. Modern business organizations cannot afford to ignore modern planning much longer and once it makes use of it and the pedestrian traffic is controlled into a market of steel and glass, the individual store front will disappear. Arcades have been used in the past to a certain extent to do away with the lack of unity in our modern streets, but they are unpopular, because of the competitive individualism of the shopkeeper combined with the remoteness from potential customers. Since the arcade is unpopular and always will be we must turn to some form of the multiple store, where the ground floor will leave the maximum accessibility for the customer, and each floor

will have its outside promenade. Thus the screen walls will be almost entirely of glass providing a series of windows at every level and the entire building will be as natural a promenade as the street. That glass will do much to bring about such an improved arrangement goes without saying.

Individualism in shop fronts is our problem today. All too often the clients' wish for an individualized front eliminates any effort at conformity with the street in question. The present tendency is to enclose the shop with an illuminated stage running the entire width of the frontage.

The unsympathetic use of plate glass in shop-fronts that continued throughout the nineteenth century into the twentieth and looks as if it will continue has been criticized very severely by all architects. We have all seen instances where the upper stories of a business building looked as if they were supported by glass. Plate glass is not at fault in this architectural crime, but the fact that designers have not used it in the right way. It must first be realized that for all intents and purposes glass is invisable. From this one can easily reason that a show window must be regarded not as a two dimensional surface, but three dimensionally as a recess, and treated as a portion of the exterior.

The metal frame has had an enormous effect on architecture, generally to its advantage. With a standardized unit, it is possible to use them in a most flexible serial manner. This has been one cause for our increased liking for horizontal effects. Before the first World War metal frames were generally used in houses of a traditional character and often disguised with mullioned openings and leaded lights. The metal frame offers innumerable possibilities of fenestrational treatment-thus the vertical or the horizontal can be emphasized-the window can be set back far from the face of the wall or cantilevered out from it. With such varied possibilities, architects all too often, use whatever is popular at the time.

The effect of the larger window is that of giving increased spaciousness to the room, especially when incorporated with mirrows. "Large windows do not only apparently increase the spaciousness of a room; they make an actual perceptible addition to it and also, by reason of the incompatibility of the window and adjacent furniture, render a good service in thinning out the furniture and leaving at least one wall uncluttered with paraphernalia. It is remarkable that as the window-space increases the amount of furniture decreased. Whatever the reason for this, whether it is because

the window demands an open space or because the decrease in furniture is a parallel symptom of the desire for space, there seems to be this incompatability, though cynics would say it was due to the unsympathetic nature of glass, which in cold weather, drives the comfortable chair away from it. Actually the most probable reason is a psychological one. At its simplest it may be stated as a shifting of the focus of interest to the window from the fireplace, or rather the change from a local secluded interest to a distributed active interest. The large window, often taking up the entire wall, has, with the complementary distribution of heating, emancipated us from the fireplace, has sometimes eliminated it, and in the upsetting of our long established notions in the course of this has led to the evacuating of a large number of non-essentials among the furniture.

The window says Corbusier, "has for more than two thousand years been fighting for the greatest possible dimensions against the limitations imposed by building materials and methods of construction." At various times it triumphed over these limitations as in the Gothic architecture, but always for there was a compromise because of stylestic reasons. In the past century iron frame construction made possible the complete

liberation of the window, but academicism delayed the outcome for almost a hundred years. Glass walls- walls composed of a wide span of steel members whose intervals are filled with glass, are coming into their own today. The nineteenth-century architect used half a dozen styles, but always the available large sizes of sheet glass emphasized the awkward appearance of their works. There was a feeling of nakedness caused by the elimination of the division bars and conflict of scales. It was realized that division bars often barred the view causing a very disagreeable condition." "For any adumbration of the modern 'liberated' window, one may search the architecture of the past fifty years in vain. It is, in fact, less than a decade old, younger than the plate windscreen of the motor car." (Glass in Architecture and Decoration - Raymond, McGarth and Frost).

It has been the architectural habit of introducing some form of decoration in and around the window. Where the window has been treated as one of a series it often fulfilled an essential service of repetition in an otherwise uninteresting facade. Ornament has often made up for the deficiencies of the window, but too often caused the window to be regarded as a mere unit of penetration and not one of giving light. The smaller the window

the blacker it appears, and consequently many division bars were used, but as soon as huge expanses are used, as in truly modern work, there is no longer a dark void, and consequently no need for glazing bars. In Corbusier's "Clarte" at Geneva the window is the wall and compromise is eliminated, if it does not occupy it altogether; it also means that it has changed from an upright emphasis to a horizontal one, and consciously or not the shape of the furniture is usually made to conform to the dominant shape of the window.

How big shall a window be is a difficult question, but it is probably most logically answered by using glass completely in the fourth wall of a room producing a window which can be modified to admit as much light as required. The important consideration is to get the glass high enough to illumdnate the whole depth of the room. Corbusier uses the very interesting principle of using a ceiling height of fifteen feet in his residential work and then divides the rear half of the room into two floors, because all you need is to make adequate provision for admission and penetration. Thus the room is a sort of light trap where the light is well and truly caught.

The external wall of a modern frame building acts merely

as an insulating screen supported by the wall beams, or the cantilevered floor. Its thickness needs only be governed by the insulating value of its material. Steel frame windows are frequently attached to this screen. This window frame may very conveniently be used in bands, explaining the reason for many of our horizontal window bands.

Opaque glass over solid walls has recently become quite popular. The opaque glass is usually rolled opal, and is bedded in a ¼ inch thick bed of special mastic laid in dabs covering at least ninety percent of the area. Rolled opal glasses have a ribbed back which is intended to improve the key between the glass and mastic. The mastic takes care of the strains set up by the movement in the structure of the building. Experience has shown, however, that mere reliance on mastic fixing in the case of large external areas of glass is an "invitation to disaster". No one can guarantee mastic an indefinite life, and for this reason metal covered strips are employed to clip all edges of the glass. Opaque opal glass absorbs heat according to its color. Whatever the expansion, the temperature strains set up in the glass must be relieved.

Interior uses of glass are numerous for the increased window area of modern buildings leads one naturally to wish one to complement this external treatment with facings of opaque glass over the solid walls. There are also many portions of the interior where a durable and impervious material is equally desirable, where hygienic, labor-saving surfaces are essential. Rolled opal glass is now used extensively in bathrooms, lavatories and kitchens, in bars, restaurants, swimming pools, hospital wards, and operating rooms. Rolled opal is impervious to all common organic and inorganic acids, except hydrofluoric. It is also unaffected by a large number of stains, including blood.

Aesthetics of our modern architecture has been debated but the following description of Corbusier is convincing: "The Cité de Refuge stands today a brilliant example of the two contemporary idioms ....The north front of the main building presents a blank wall except for several light shafts. The south front presents one complete expanse of glass which passes in front of the cantilevered concrete floors. The glazing of each floor is divided into three horizontal strips, the lower strip being wired rough-cast glass of a pinkish green color, the remainder polished plate, clear or acid-obscured. The glass front of the refractory floor is divided into alternating bays of plate and

"nevada" lenses, sections of the plate glass being arranged to slide behind the "Nevada" lenses so that this portion of the building may be thrown open in good weather. The entrance portico is an ingenuous and airy structure with one "Nevada", the lenses of which are built up in panels measuring 10 feet, 8 inches, by 15 feet, 4 inches. The portico is faced outside with white glazed brick, and is lined inside with "virre-mural" in large squares of gold yellow, French blue, and deep crimson. One half of the circular wall of the entrance hall is a translucent curtain of lenses. The dispensary underneath it is lighted in the same way. The re-inforced-concrete floors and roof slab of this circular block are supported on four stanchions which are set back about four feet from the wall face. With a shock of surprise one notices a green fringe of grass appearing over the edge of the parapet and discovers on inspection from above that it is laid out as a formal garden. Buildings like this, in which good taste and imagination have been so happily informed by constructional knowledge, are rare indeed. There is no need to imagine the logical part which glass will play in the future. It can be seen in Corbusier's Cité de Refuge, this building which, thanks principally to the benificence of Princess

Singer de Polignac, has been realized twenty, thirty, or fifty years before its time." (Glass in Architecture and Decoration - Raymond, McGarth and Frost)

Transmission of heat through glass has an important bearing on the heating of buildings. This transmission of heat energy must be taken into account according to the aspect of the building and the type of heating system employed. Gropius has stated that the heating costs in his famous Bauhaus were only eleven percent more than in the Dessan Town Hall, an ordinary brick building with small windows. Tests have been made which reveal that thickness variations of glass do not materially affect the amount of heat loss. Double glazing, however, results in a reduction of at least half of the heat loss. In Europe they have long practiced double glazing, especially in windows with northern exposures. Patented double-glazed units have been developed. These usually allow an air space of at least one inch between the two sheets of glass. In these installations care must be taken to dry the air space between the glasses, so that there will be no condensation. Hollow glass brick also provide a form of double glazing. In many building it is desirable to exclude the sun's heat,

but it is never desirable to exclude light as well. These conditions have lead to a heat absorbing glass, a typical one being Calorex.

Ultra-violet radiation has been proven to have very beneficial physiological effects. Unfortunately, ordinary glass has been found to be completely opaque to these rays, and soa special glass has been developed. These glasses are used in modern hospitals, either in the wards or in specially constructed balconies. Particularly now that people are living indoors more and more, it is necessary that all the qualities of sunlight be reproduced into our interiors.

Light transmission is the essential quality looked for in most of our uses of glass. There are three types of distribution of light - (a) light incident normally on the glass, (b) completely diffused light such as that received on a horizontal roof from the sky, (c) restricted diffused light, as in the case of a vertical window facing a street in which the angle of elevation of the opposite building is 45°. All roof glazing and some window glazing is done with a glass which is itself a diffuser. The result is that light is scattered more evenly although some is lost in intensity. The diffusing value of glass depends upon its surface and the direction of light.

Prismatic glass has been developed to redistribute the light at a given angle. Prismatic glasses have been designed with the object of blending the daylight so that it passes more horizontally to the interior of the building. Prismatic glass is an example of controlled light transmission while the non-reflecting shop-window is an example of controlled light reflection. The most successful non-reflecting window is a bent plate forming a part of an ellipse, the foci of which are so arranged that no reflection of himself or his background can be seen by the observer. In the ordinary straight plate-glass front the reflections of the street are very distracting. Artificial illumination of the interior of the window sufficient to kill these reflected images would be wasteful and difficult to install. The non-reflecting window, although more expensive at first, is a valuable solution to the problem. As the pictures in most public galleries are now under glass the defect arises from the fact that the spectators are frequently much more brilliantly lighted than the hanging space and are consequently powerfully reflected in the glazing of dark portion of pictures. S. Harst Seager, who has done much research as the subject suggests that, "the best form of daylight is one double-glazed, with

clear glass on the outside and at a distance of four inches from it an inner sheet of Kaleidoscope glass forming an airtight and, of course, dustproof space in which the blinds can work." In American galleries elaborate double glass roofs have been fitted with daylight lamps and dimming apparatus so that artificial lighting can be made to replace the waning daylight without any noticeable change.

Glass brick have made possible the construction of glass walls. There are many types of glass brick; among them being the new Owens*Illinois hollow bricks, which consist of two diskes sealed together at a high temperature, the process creating a partial vacuum. The mortar in which these brick are laid is important, for too rich a mixture swells when water has been absorbed and fracture of the bricks results. The faces of the brick are usually so designed that light coming in will be broken up and scattered, so as to give better distribution than ordinary windows. The brick are especially adaptable to partition walls required to transmit light and for subdividing large rooms which have light on one side only. They are also good for workshops, studios, and laboratories where the work is distributed over the whole space and uniform light is essential.

Glass block are essentially massonry and should be used as such. While it does let light in, that is the only relationship to a window. It is the wrong expression of the material to use it as a window opening rather than as one would brick. Glass brick are best treated as a translucent wall. It is often difficult to combine successfully with clear glass. In America we are using glass block more and more, and there is little doubt that "the air-conditioned city building of ten years hence will be walled with glass block".

Multicellular glass is just emerging from its experimental stage. According to Dr. Bernard Long at the International Congress on Glass held in London in 1936, "Multicellular glass is a light material having a high resistance to compression, and is therefore likely to be applied in brick form to the construction of thin insulating partition in buildings or in slab form, as heat-insulating linings. The surface of the brick provides a good key for plaster. The linings, which are slabs, are bedded in plaster and may be sawn or drilled without fear of fracture." It is obvious that the sphere of glass in architecture can be widened considerably by the use of this material.

Wired glass has been developed for protection against breakage. This glass is not stronger than ordinary glass, but the wire merely holds the sheet of glass together. Wired glass is used for large exposed areas where fire protection is necessary as well as safe working conditions. There are various patterns of wired glass available.

The union of glass and concrete came about quite naturally and leaves yet much to be developed. The first practical glass and concrete constructions can be attributed to the German Friedrick L. Keppler, his invention being known as the "Keppler system". This system has been greatly improved but the following will help one to understand the principle upon which all such systems work. "The overall depth of the penses varies between 40 and 60 mm. The steel reinforcing rods are up to 122 mm. in diameter. These rods which are bent at end end are used as cross reinforcements in the slab to take up and distribute the load tension. In order to pervert edge straines due to general shrinkage the lenses are spaced slightly apart by inserting cardboard strips 2 mm. thick. A slow setting Portland cement is employed as well as a waterproofer. A minimum side bearing of 5 cm. is provided for all slabs. The

shuttering is set up and the lenses are placed in position with, as previously described, a long cardboard strip running the narrow way of the slab laid between the lenses and shorter strips between the lenses at right angles. Wedge-shaped varnished wooden laths are used to form expansion joints. The reinforcing rods are placed in position. The strength of the slab, as in all reinforced concrete work, depends upon the accurate placing of the rods. The cement concrete is first run and well rammed into the side bearing round the slab, next between the lenses. It is smoothed off, the tops of the lenses cleaned, and the whole slab is covered with wet sand. The laths forming expansion joints are removed, the cardboard strips raked out and the lenses cleaned." Glass in Architecture and Decoration - Raymond, McCarth and Frost. This system, however, does not lend itself to curved work, nor does it withstand the extreme changes in temperature. These disadvantages led to the development of a system of glass and concrete construction in which the lenses were carried on rebated concrete bars, and in order to withstand severe temperature changes a related lens was designed for the insertion of a flush waterproofing layer of asphalt. This construction is suitable for small spaces, but for larger ones it would stress the glass too much, and so the Luxfer asphalt-

glass-concrete roof has been developed, in which larger size lenses may be used, but they are laid in a plastic bed of asphalt independent of the concrete supporting structure.

Decoration is in much disfavor in our present age because too often in the past it has been decadent, barbarous, and useless. "Though not so virulently puritanical as many, we are austerely suspicious of this architectural scarlet women whore of Babylon, etc, etc. In the eighteenth century, of course, she was an ennobled courtesan, a royal mistress, even a sympathetic bluestocking, but since then there has intervened a very sordid period affecting everybody and implicating personages of otherwise unblimished character. Therefore we have abjured her embraces, mostly out of fastidiousness - though we call it virtue - and reformed our rooms down to bare essentials, conceding ourselves a lonely object d'art as a mortification to the spirit. And as we are in a very small minority we are perhaps embittered as well as righteously fortified at the sight of millions of our fellows mortals going exuberantly to the devil in the worst taste possible." (Glass in Architecture and Decoration - Raymond, McGarth and Frost)

Glass is an integrally decorative material and therefore has escaped the purge against decoration. Even though we no longer like a rich assortment of "pièces de resistance" we do crave color, and textures, responsive to light and shade. Glass can take any color, and any surface treatment. It is capable of fine finishes, and may be from complete transparency to opacity, as well as perfect reflection to a matt surface. There is hardly any surface treatment that it cannot assume. Yet at the same time it always retains its glassy nature, whether it is embossed, engraved, painted, sandblasted, mirrored, moulded, or blown. Of course, there is much exploitation in the use of glass, but this is equally true of all other materials. Since glass is a material capable of endless adaption, and is a material decorative in itself it passes all the severe tests imposed upon it by architectural puritanism.

Glass mosaics were used first since glass developed its transparent qualities comparatively late. The assembling of small regular or irregular units of glass, brilliantly colored, has a long history, example of note having been found in ancient times. The Egyptians, Greeks, and Romans all concentrated chiefly on pavement mosiacs in which there was little opportunity for the use of glass. However, in early Christian

art we find a wonderful technique developed producing murals and patterns which to this day are still associated with the church. "When Christianity emerged from the catacombs to become the state religion, it brought with it the art of mosaic already stamped with that bold stylization equally appropriate to the limitations of mosaic and the symbolism of religion. For the glorification of its churches it provided an obvious medium, especially as its impressiveness and richness of tone had already been demonstrated in the dim lights of catacombs little darker than the new basilicas." (Glass in Architecture and Decoration - Raymond, McGarth and Frost)

Mosaics as mural decoration rivals oil and frescoe painting because of its permanency and glowing richness of tone. Perhaps the greatest evil a designer in mosaics can commit is that of trying to reproduce the effect of an oil painting, which has so often been done. As in all glass the relation of the mosaic to the source of illumination must be given much thought. The units must be arranged so that they catch the light from different directions or reflect it at different angles and so bring out the sparkle and depth of color which could not otherwise be obtained. In most cases a bright diffused light is inappropriate because it does not

bring out the textured surface so much as a more lateral direct source might produce. Mosaic is a craftsman's art and therefore has been criticised by some modernist. For eight hundred years, ever since it was ousted by painting, it has been unsympathetically used by restorers and imitators. Its secularization has done much towards instilling new life into the art. Its stylized expression and dominance of pattern over subject matter should surely appeal to our modern trends in design.

Vitroflex is the name given to mirrored or opaque glass laid on a fabric and cut into rectangular unit sections varying two inches square, to one inch square as well as various rectangular shapes. The fabric backing is attached to the solid which it is decorating and so becomes a part of it. Vitroflex is especially adapted to restaurants, shops, cocktail bars and other places where gaiety and sparkle is intended. Screens have been executed in this material with very pleasing results. It is very flexible and can be used on concave as well as convex curves of not too great a radius. The lightness of the material, as compared with structural glass, makes it suitable for ship interiors.

Our modern stained glass offers the most brilliant opportunity for expressing glass in a decorative manner. Stained glass windows are intolerant of other decorative color in the interior they illuminate. Just as we visualize Greek architecture as originally bleached and naked as it is now, so we think of the medieval cathedral as bare except for the windows. Actually this was by no means true. He further ornamented his churches in a way that would make many of them barbaric in our eyes. In the modern church there has been a perceptible increase in the austerity of church decoration in the last few years. "The absence of sensuous appeal - the "purism" - of great contemporary movements in architecture, house furnishing, sculpture, painting and design, proceeds ultimately from the same source as the new evangelism." Wyndham Lewis - The Architectural Review, November, 1930. In many cases color has been banished from the church window, and the windows themselves have been reduced in size and importance. It is odd that now, when with new materials we can achieve that lightness of construction which the Gothic builders did their best to obtain, we build with solidarity and sobriety that might have typified their age rather than our own. Gothic, perhaps unfortunately, lost its reputation by the crude imitations of the nineteenth century, and for

some reason the stained glass window followed a similar fate. Actually the modern church interior, with its bare unornamented walls, provides itself with an ideal frame for the richness and radiance of stained glass. After this has been realized, the biggest problem is that of iconography rather than technique or art. To recapture the spirit of medieval imagery is impossible for us - we can only reproduce it. "Nowadays, it is felt that the subject and significance should be wholly religious, but since there appears to be little unanimity between religion and art the result is more often than not a deliberate attempt to disguise the inadequacy of one or the other under cover of a cautious or sentimental adaption of medievalism." "Modern glass painting, owing to the confusion by the artist of the many difficulties, psychological, technical and what can only be called iconographic - the difficulty of creating afresh the 'dramatic personae' of Christian symbolism - offers very few examples. It is surprising that modern art, in its reaction against humanism, has not attempted something analogous to the idealogy of medieval art. The asceticism of the modern artist appears to be merely a protest against the facilities of humanism, a corrective at its best and at its worst an inducement of automatism."

Secular applications of stained glass is used very little because of its exclusive religious associations. The church windows of the Middle Ages was imitated in the houses of the wealthy, using heraldic panels or decorative medallions, but always a rather sober adaption of church windows. Leaded glass, an offspring, has performed the task of obscuring the view from a window with an undesirable outlook.

Since the first requisite for a mirror is that the glass shall be perfect the development of the mirror was delayed muchly. Though mirrors were known to the ancients, they were not common, metal mirrors being used much more than glass ones. The medieval mirror was so small that it did not lend itself to decoration. The reason for the preference of convex mirrors was because of the ease with which a spherical shape could be blown. In the eighteenth century the frame of mirrors received much attention, often being treated in an architectural manner until the Adam school rescued the mirror and frame. Eighteenth century mirrors were almost always bevelled, often by hand and increasing the decoration affect. The bevel of modern glass is much deeper and shows the prismatic colors and, of course, is all done by means of machinery.

The modern method of silvering is usually done by the chemical deposition of silver. Glass for silvering must be examined under critical lighting conditions, since silvering accentuates all defects. The layer of silver is very thin and comparatively delicate "In the deposition process two solutions are employed - a solution of some silver salt, such as silver nitrate, and a reducing solution. These solutions are mixed immediately before being poured on to the wet glass, which has been washed beforehand with stannous chloride and then with distilled water. A cold or hot process may be employed and the metallic silver is deposited on the surface of the glass after a period varying from three minutes in the former to twenty minutes in the latter process." (Glass in Architecture and Decoration - Raymond, McGarth and Frost).

There are other metallic backings for mirrors all of which are a little difficult to work with. Gold as will aluminum may be deposited electrolytically, producing very beautiful effects. Very beautiful gun metal shades are obtainable. Gilding with ordinary leaf produces some very delightful effects. It is also possible to use tinted glass, instead of clear glass, and use ordinary silvering a whole new range of color effects can be produced. Mirrors of a warm

pink or pale gold tint which flatteringly reinforce the natural color of the spectator have been found to be very popular, although one must be careful that the mirror used changes only the tone and not the color of the image. But more often mirrors of grey or black polished plate are more restful and better to use, they being the counterpart, on a larger scale, of the "Claude Lorraine glasses". These Claude glasses were little convex mirrors, about four inches in diameter and backed with black foil. As Christopher Hussey remarks in the "Picturesque": "The slight convexity of the glass gathers every scene reflected in it into a tiny picture, and, by reducing the colors into a lower ratio, accentuates the tonal values". Our grey plate mirrors do the same thing by reducing reflections to a lower key, and so we see things in a new light. The surfaces reflections on still water are not unlike those on polished black glass and it seems seldom appreciation that in any interior such sheets of reflection may be as effective as lakes of water in a formal garden.

The "vista mirrors" were early realized to be of great decorative value. At Versailles the long corridors are often prolonged by axial mirrors, and so they quickly enlarge the space. Vista mirrors, or mirros

placed face to face, make possible an infinite prolongation of the room's perceptive, but one has to guard against distortion, which is very easy to happen in case the mirrors are not exactly parallel to each other. Although it is possible to get glass in twenty by twelve foot dimensions, we often have to use mirrors which are built up in sections. Again one has to be careful to retain the continuity of the image. There are many examples of walls of mirrors used to continue the room and make unnoticeable many defects. Mr. Repton in his "Fragments on the Theory and Practice of Landscape Gardening" says: "I have made use of mirrors, so placed, to introduce views of scenery which could not otherwise be visible from a particular point of view."

The mirror has long been used for gaiety in places of entertainment and especially in restaurants. No other wall decoration can compare with it in loveliness. The female patron always needs a generous looking anyway. Le Tricaphe in the Champs-Elysées is quite noted for its use of mirrors. "Its toned pink ceiling in shell-like formation is supported by one piece mirror columns approximately eighteen feet high and glass columns with sprayed lacquer designs in browns on a hand-leafed lemon gold and

silver background. From inside the cafe one looks through the great vertically sliding plate-glass sashes over the red chairs on the terrace and under the red and white stripped awning into the avenue. The entire decorative scheme is conducted with an exhilarting gaiety and directness of attack." (Glass in Architecture and Decoration - Raymond, McGarth and Frost).

The mirror can be used in window displays to a great advantage. Psychology has proven that more people will look in a window which has a mirror, while a distorting mirror will probably cause a congestion along the thoroughfare. Since the window is for display too many reflections will only serve to confuse. The mirror should therefore be modified, and possibly moved to the sides of the windows where it will provide an added view of the exhibit.

Lighting is dependant upon glass more today than ever before. The connection between glass and artificial lighting is an obvious and an ancient one. The invention of English lead or crystal in 1673 led to the production of a metal that lent itself to cutting far better than any other glass and so we had the Chandelier. The chandelier developed into something very beautiful until we started using electric lights

in the shape of candles. This has been much of the cause of the disfavor of the chandelier, but, of course, it was not the glass which was at fault but the way in which it was lighted. The inherent brilliance of a piece of cut glass has no rival and there is no reason why this quality should always be "coyly hidden" under an unbroken surface. The present trend toward diffused light limits the use of cut glass in connection with lighting, but there are times when it could be used with much propriety. The Radio City Music Hall has some beautiful crystal chandeliers, each twenty-nine feet in length and approximately two tons in weight. There has been a gradual elimination of accessory details until modern lighting fixtures are frequently little more than a simple globe. To obscure the dazzling light source of modern lighting there are various kinds of glass available, the most successful being flashed opal, which gives a uniform surface brightness.

Directional lighting is the modern preference taking one of the following types: semi-direct, general, semi-indirect, and direct. Translucent opal plays an important place in each of these types. Often the success of lighting depends to a great extent on the diffusing power of glass. The illuminated panel is very common today, often being placed fleech

with the ceiling or wall and making use of flashed opal which eliminates the irregular light effect. There has been in recent years a very definite attempt to organize lighting and make it an essential part of the design, a subject outside the scope of this work. It is interesting to note that the large glazed surfaces of so many modern buildings allow the interior lighting to act as a definite design element.

Glass furniture has innumerable applications because of its protective transparency and its imperviousness to most acids and stains. Clear plate is used for table tops, shelving, sliding doors, folding screens, and showcases. Of late there has been some furniture vulgarly veneered with mirrors. Such furniture is never utilitarian, but sometimes for display purposes its elegance is justified. A glass chair, with delicate tapering legs veneered and mirror, standing upon a floor of polished black glass with a white velvet gown thrown almost carelessly over it, is an object which excites.

Engraving, cutting, brillant-cutting, and bevelling are all forms of the same process of abrasions with grindstones, large or small. Thus engraving is an art depending on the skill and touch of the engraver,

brilliant-cutting is a more mechanical large-scale version of engraving still dependant upon the brilliant-cutters' skill, whereas bevelling may be executed entirely by mechanical means.

The etching of glass is a process whereby glass is obscured by dissolving its surface in some solution of hydrofluoric acid, the only acid which will reapdily attack glass. An almost infinite variety of obscuring textures may be obtained by this means and these in combination have decorative possibilities which have never been realized. These finishes are white acid, satin and stipple, as well as various combinations of these. These finishes have practical as well as decorative uses. Stippling is employed extensively for screens and windows where the greatest amount of light is needed but where obscurity is also essential. Satin finish is extensively used in the windows of operating theatres, because it obscures but is also easily cleaned. The stippled finishes are obtained either by coating the surface of the plate with a thin layer of gum arabic, over which is scattered a layer of ground mica before embossing. As a result the acid is more active where the mica has not settled on the surface. In carrying out an

embossed design Brunswick black is commonly employed for this purpose. Very complicated means are resorted to in order to arrive at certain effects in embossing.

Sandblasting is a process which has been until recently neglected for before 1870 it was an unharnessed force. Sandblasting was first applied industrially for engraving inscriptions and designs on mass produced table glassware, a form of which was subsequently used in plate glass, marble, and granite. There are various effects obtainable by the process, but there are two broad classes into which the work may be divided - 'surface' sandblasting and 'grave' or deep. These treatments are frequently combined and form a very wide range of effects. Apart from the standard matte tones which are obtainable, surface sandblasting allows of more delicate gradations, sanded tones fading into the polish of the plate, the most delicate tones being produced. Shaded sandblast is usually done on polished coloured opal, often black. Polished plate glass in ordinary thickness is apparently colorless, but thick plate glass is appreciably green, so that, looking at it edge on, the natural color is much intensified. The characteristic green may be used brilliantly by the designer. Deep 'grave' sandblast is a sculptured medium of expression and

there is no reason why 'grave' decorations should be limited by anything but propriety and the manufacturing size of plate. One can visualize a great entrance hall with monumental 'grave' design on floor to ceiling screens. So far we have done nothing.

Pressed glass allows for a method of mass production and repeat ornaments. Plaster models are prepared, and an iron mould manufactured. The cost of this mould is so high that pierced glass is about limited to work permitting of repetition. The most monumental example of pierced glass decoration is the 15 foot by 55 foot panel varying in thickness from 1¼ inch to 4½ inches, which was designed by sculptor Lee Lawrie for the main entrance to the principle building of the Rockefellow Center in New York.

Glass in decoration has been used very little, chiefly because of the lack of opportunities and the decline of technical knowledge of the artists themselves, being content with more convenient forms of drawing and painting. They have not been tempted to experiment "in terms of the expressive potentialities of a particular kind of a particular material, such as glass". We are the poorer because of this aloofness. Yet glass is undoubtedly the material which will contribute the chief decorative enrichments to the building of our times.

Glass is an efficent structural material with regard to weight that we have. The dead weight of a given material is of great importance in modern building. The compressive strength of structural glass when used in small areas, is high - the ultimate compressive strength of small glass units reaches 65,000-85,000 pounds per square inch; its ultimate tensile strength is approximately one-tenth of that.

Glass used as an integal part of the structural system becomes necessary after a certain point or by merely a surface material supported by a skeleton as in a greenhouse. Glass will always be used primarily for its ability to control light, but this fact should not obscure its potentialities in another field - that of load bearing. America has, of course, seen an extensive development of glass bricks, tiles, and prisms in the last decade, but they have to be combined with other materials which really do the supporting. The elliptical dome of the Sport Theater in Berlin by March; the Chechoslovak Pavilion at the Paris World's Fair in 1937 by Krejcar; the Technical Museum in Prague by Babuska, are examples in which glass is no longer merely a surfacing material but an integral part of the structural assembly, carrying its full share of compressive and tensile loads. Three materials - glass, concrete, and steel - have been

combined into a new material which exploits the desirable properties of each.

Transparency and its brilliance are usually considered as most characteristic properties of glass. Actually, transparency is by no means an essential property, as is shown by the opaque glass of our day. Brittleness, on the other hand, appears to be a very characteristic feature which can only be modified within very narrow limits. It is impermeable to water and resistant to attack by ordinary weathering agents; it has a brilliant surface, and it lends itself readily to large-scale production.

The durability of modern building glass under ordinary conditions is so excellent that the possibility of deterioration is usually ignored. Water is the most active atmospheric agent which works on glass. An effect of roughness of the exposed surface is noticeable when this occurs. The resistance of glass to weathering will obviously depend primarily upon its composition, certain silicates being much more readily attacked by water than others, but the rate and extent of the weathering action for a particular glass is determined very largely by the condition of its exposure. The amount of dirt which is allowed to remain on glass is also a factor of major importance, for the dirt film is porous and is able to hold water in contact with the glass surface.

The strength of plate and sheet glass is somewhat difficult to ascertain because of wide range of conditions. The moduli of rupture to be used in any computation of window sizes are therefore 2,675 pounds per square inch for plate and 5,350 pounds per square inch for sheet glass. Values for the maximum wind pressure and the modulus of rupture having been assumed, Marcus' formula enables the minimum permissible thickness to be computed for a given sheet size.

The formula may be expressed in the form:

$$f = \frac{3}{4}\frac{wb^2}{t^2}\left[1 - \frac{5}{6}\frac{n^2}{1-n^2}\right]\left[\frac{1}{1+n^2}\right]$$

Glass usually fails in tension, the strength of glass usually being determined by its surface. Cracks always start at the surface and develop inward. Glass is always found to be widely variable in strength, largely because of the number of flaws always present. The edge treatment affects the strength of glass sheets - specimens with diamond-cut edges, subjected to a transverse bending test are much stronger when the diamond scratched surface is placed in compression than when it is in tension. It has also been found that glass grows weaker when under sustained loading. Wired glass is no stronger than ordinary glass, but it has the great merit of holding together when cracked, except under heavy impact.

The transmission of sound through glass areas is considered to be a weak point in building. Sound reaching a partition as an air-borne vibration may be transmitted either by direct air-paths through cracks or gaps round the edge of the partition, or the causing the partition to move or vibrate as a whole and so to imitate a sound wave on the other side. Ventilation and sound insulation cannot be obtained simultaneously by ordinary windows, therefore we should do all in our power to get well-fitting windows so as to reduce cracks. The sound insulation of well-fitting, closed windows is governed principally by the weight of the glass, although it is impossible to reduce much loud traffic noises. Where a high degree of insulation is required, double windows must be fixed. Glass is an efficient reflector of sound and consequently may be employed to form reflective surfaces in auditoriums.

Too often a conclusion is merely a link between the nothingness which has preceded and the nothingness which is to follow. I am sure that I have proven nothing concerning the theory of glass and its relationship to mankind. However, I do feel more certain that glass will influence our architecture in the future and two thousand years from now we will be noted for our brilliant use of glass, to gain that space feeling and aesthetic satisfaction - always the important architectural objective - that is now possible. Because glass is integrally decorative, it will also serve to relieve the starkness which the layman so often connects with our works which are not studies in archeology. I have not touched and only dimly dreamed of the beauty which may be caught in the future by men of genius and sincerity of purpose.

The New Architecture - Roth

Glass in Architecture and Decoration - Raymond, McCarth and Frost

Glass - Korn

Antonin Raymond - His Work in Japan

Circle - Faber

Pencil Points 14: 306 - 8

Pittsburgh Glass Institute Competition report - August, 1937

Glass, Structural Material of Tomorrow - J. Polivka, Architectural Record 85: 65 - 72