Glass, the Fundamental Material of Modern Architecture
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Glass, the Fundamental Material of Modern Architecture

Le Corbusier
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Introduction: Struggling with the *Pan de Verre*

Within the modern movement of the 1920s, there were broadly two distinct ways of responding to the opportunities presented by the industrial production of large sheets of glass. For Le Corbusier, for whom "architecture is the masterful, correct and magnificent play of volumes brought together in light," the primary function of the window was to let in light.[1] In an important article summing up his aesthetic after the completion of the Villas La Roche–Jeanneret, Le Corbusier stressed the function of illumination:

> With reinforced concrete, there is no need for a framing wall. The window can run from wall to wall and illuminate them all over.
>
> Now the room is full of light because the walls are illuminated. There are no walls in shadow or half-light. Our senses are enchanted; our animal being is delighted. We have the sun in our room. It is bright in our house.
>
> And we say: Our house is cheerful.[2]

In his Purist work Le Corbusier wanted to treat the interior like an exterior, creating effects of light and shade, volume and space. The big window illuminating the hall in the Villa La Roche had the effect of bringing an external quality of light into the interior and emphasizing the continuity between the external facades and the internal walls (fig. 1).

Fig. 1
Le Corbusier and Pierre Jeanneret, Villa La Roche, Hall. © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC. Photo: author.

The main emphasis in the German and central European approach to the window had a similar result but a different starting point. The articulation of illuminated volumes in the interior was less important. Effects of weightlessness and of insubstantial diaphragms of glass were increasingly emphasized, enhanced by the tradition of photography encouraged by Moholy-Nagy at the Bauhaus and by the taste for night photography. The tendency, expressed in Moholy-Nagy's *Von Material zur Architektur* and Giedion's *Bauen in Frankreich* (both published in 1928), was for architecture to become dematerialized.[3] This is a long way from the physical sensuality sought by Le Corbusier in his Purist work.

Le Corbusier's Cartesian habits of thought led him to search for the universal, underlying principle behind any phenomenon. The perspective of his Domino house project (1915), widely publicized in his *Esprit Nouveau* articles from 1920, is a striking demonstration of the separation of structure from enclosure. The logical extension appeared to be to create walls entirely of glass. In the Purist villas, the type solution for the window was the *fenêtre en longueur*, reaching from wall to wall, framing the landscape and providing space below for cupboards and radiators. But with the projects for Centrosoyus (1928–29), the Swiss Pavilion (1929–32), and the Salvation Army building (1929–33), Le Corbusier experimented with the *pan de verre* (window wall). The origins of the *pan de verre* in Le Corbusier's work go back to the League of Nations project (1927), where the sides of the great auditorium would have consisted of two walls of glass, spaced widely enough for workmen to circulate between them (fig. 2).

As Le Corbusier explains in this article, letting light in was not the end of the story. There were the questions of thermal insulation and balancing the desire for a view (transparency) with a need for privacy, and the problem of ventilation. Le Corbusier and Pierre Jeanneret had tackled all these problems piecemeal by 1934. The use of translucent glass, providing illumination but protecting privacy, had been used as early as 1923–25 in the maisons La Roche–Jeanneret. Most of the windows overlooking the neighbors were fitted with frosted glass, admittedly in a reluctant response to their complaints. Le Corbusier was quick to employ the beautiful Nevada glass tiles introduced by the St. Gobain company in 1928. Pierre Chareau and Bernard Bijvoet used them in the Maison de Verre (1928–30), and Le Corbusier probably saw this building in construction. They already appear in many of his projects for the maisons Loucheur (1928–29), the Swiss Pavilion (1929–31), his own apartment (1930–33), the Salvation Army building (1929–33), and the Maison Clarté apartment

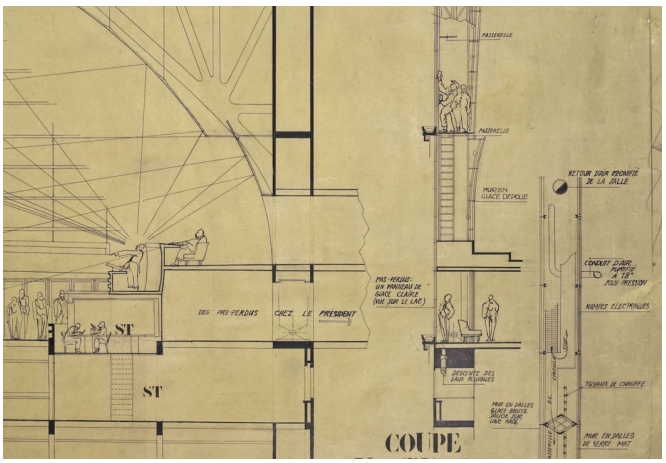

Fig. 2
Detail of section of League of Nations competition project (FLC 23168A). © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC.

building in Geneva (1930–32). The Nevada glass brick became a fetish of the 1930s, and most architects had at least one on their desk as an ashtray. Walls constructed of Nevada glass tiles produce a beautiful diffracted illumination while ensuring privacy and protection from burglars (fig. 3). Le Corbusier placed a panel of Nevada glass tiles in front of his desk in his studio, presumably to avoid being distracted by the view while he worked. Although the technical literature claimed that the coefficients of expansion of glass and concrete were very close, the fact is that Nevada glass tiles exposed to direct sunlight crack spectacularly.

Thermal insulation was a different problem. Although the first project for the Citrohan house included cavity walls, Le Corbusier and Jeanneret seem to have paid little attention to thermal insulation in their Purist architecture. No doubt they considered the Parisian climate to be temperate compared with their native Switzerland. The 1920s villas could rely only on the mass of solid breeze block walls, and none of the windows were double-glazed. Although Le Corbusier refers to the Italian Thermolux panels in this article, he does not seem to have used them until the 1950s. In the Salvation Army building, the masonry walls did have an air cavity of two centimeters, but the south-facing glass wall was not double-glazed.

Le Corbusier had first toyed with the idea of a *pan de verre* consisting of two widely spaced sheets of glass in the design of the League of Nations Palace, no

Fig. 3
Nevada glass tiles used by Le Corbusier in the bedroom of his apartment at 24 rue Nungesser et Coli, behind his wash basin. © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC. Photo: author.

doubt under the influence of the many Swiss architects who came to Paris to work on the project with him.

The double wall also had a rather particular purpose, as it was designed to allow workmen to clean the glass from the inside. In their competition drawings, Le Corbusier and Jeanneret noted that frosted glass would be used for the glass walls except the windows of the foyer, which overlooked the lake.

While modern architects in Switzerland, Holland, and central Europe began to tackle the practical problems of insulation of large expanses of glass, Le Corbusier began to develop another theory, comparable in its Cartesian

abstraction to that of the separation of structure from enclosure. Why heat or refrigerate all the air in a building, as the Americans did? If the enclosed volume was completely airtight, all that should be necessary is to counteract the heat gain or loss from the outside by pumping very hot or very cold air through the air gap in a double window wall. This he called his "neutralizing wall." The air inside the building would then remain at the "normal" temperature of 18°C. A purification plant would constantly replenish the air inside the building through an internal ventilation system. This is what he called *respiration exacte*. The first project for the Centrosoyus Ministry building in Moscow (October 1928) included a large *mur neutralisant* combined with a system of *respiration exacte*, and Le Corbusier hoped to include something similar in the Salvation Army hostel.

Some support for this idea came from a study made by Gustave Lyon at the research station of the glass manufacturing company St. Gobain.[4] In laboratory conditions a "cold room" refrigerated with dry ice was separated from a warm room by a double window through which hot air was pumped. In his lecture to the fourth meeting of Congrès Internationaux d'Architecture Moderne (CIAM) in Athens (August 1933), Le Corbusier had set out a passionate argument for his neutralizing wall and precise respiration. Admitting that no one, not even modernist colleagues in CIAM, had thought his ideas plausible, he triumphantly described a visit to the St. Gobain laboratory in the company of Gustave Lyon in 1931. After a brief description, he announced: "In short: this is the verdict: the principle of 'precise respiration and neutralizing walls' is a practical possibility."[5]

Following the publication of this lecture in the October 1935 issue of *L'Architecture d'Aujourd'hui*, a brief extract was given of a piece by J. Le Braz, first published in *Glaces et Verres* in September 1932.[6] In the original article Le Braz gave a detailed account of the St. Gobain experiment. The tests showed that a gap of around ten centimeters was necessary for efficient insulation and that the heat of the air pumped through the gap must be at least ten degrees above or below the interior temperature to offset losses elsewhere. It is interesting that, in the tests described by Le Braz in *Glaces et Verres*, a third pane of glass is recommended to insulate the zone of pumped hot or cold air from the exterior and thus avoid wasteful loss to the exterior. He also suggests a complicated system of opening windows in the double glass wall, since, he says, the filtered air will never be completely pure and the glass will have to be cleaned. He noted that the system would not work well in contact with direct sunlight, since glass

is no protection against the radiant heat of the sun's rays, and consequently he recommended external blinds. The test room in the St. Gobain laboratory produced good results precisely because no direct sunlight was involved. Overall, Le Braz estimated that the additional cost of double-glazing might be amortized in around fifteen years in the Paris region, although it is not entirely clear whether he included the pumped hot/cold air in his calculations. It is clear, therefore, that the positive test results in the St. Gobain laboratory were of little relevance to the installation of the south-facing wall of glass in the Salvation Army headquarters. The brief extract of Le Braz's article published in *L'Architecture d'Aujourd'hui*, however, omitted all these qualifications.

Le Corbusier included *respiration exacte* in his initial description of the Salvation Army project in 1930.[7] In one of the first published descriptions of the building in construction, Ducret, one of Le Corbusier's assistants, noted that the system of ventilation and refrigeration was still in progress.[8] In the event, neither the double-glazing nor the refrigeration plant was included in the Salvation Army hostel. A system of pumped air provided reasonable control of temperature away from the glass wall, but the summer sun quickly overheated all the dormitories and rooms next to the window. It is interesting that, in the article in *Tchéco-Verre*, Le Corbusier discusses air conditioning but does not detail the system of the *mur neutralisant*. His failure to have the system built in the Centrosoyus and the Salvation Army hostel likely made him wary of promoting his project. Brian Brace Taylor makes clear that the double glass wall was never a practical option for the Salvation Army hostel, and the refrigeration plant was eliminated because of the very high estimates returned by the ventilation specialists.[9] The only protection against the sun was provided by cotton curtains, and at night, when the ventilation system was switched off, the air in the dormitories was stifling. Temperatures of between 30°C and 33°C were reported by the hostel doctor in the children's crèche. The reasonable solution was to open windows in the glass wall, but Le Corbusier forcefully fought against this, claiming that all that was necessary was to increase the speed of the ventilators. Despite supportive reports by Gustave Lyon and other specialists, in 1935 the authorities forced Le Corbusier to introduce forty sliding windows into the glass wall. The dream of controlling temperature by pumping hot or cold air through a ten-centimeter air gap in a double-glazed window wall died hard.

But Le Corbusier did not give up on the glass walls. Instead of trusting expensive and fickle mechanical systems, he looked to natural ways of shielding the glazed surface from the fiercest rays of the sun while still allowing the

weaker winter sun, and that of mornings or afternoons, to warm the interior. The result was the *brise soleil*—a framework of concrete shutters placed in front of the window wall. These, described in his 1935 book *La Ville radieuse*, were used in most of his postwar buildings. When bomb damage during the war required a substantial restoration of the Salvation Army hostel, a screen of *brise soleil*s was introduced in front of the whole south front, thus slightly reducing solar gain in the summer. Another idea introduced in Le Corbusier's articles of 1933–35 was the analogy of the camera. Just as a lens is "stopped down" in bright sunlight by closing the aperture iris, so a facade, according to Le Corbusier, could be *diaphragmé*. He was a little vague about how this might be done, mentioning venetian blinds and screen diaphragms.[10] A sketch accompanying the chapter in *La Ville radieuse* on exact respiration shows the solution that he would adopt after the war: the interior of the window wall would be lined with sliding shutters of plywood, cupboards, and bookcases interspersed with glass tiles and clear glass for the view (fig. 4).[11]

Another "natural" solution to replace mechanical ventilation was that of the open section, designed to encourage a free flow of air through the building. A first experiment in natural convection throughout the height of a building was tried in the first two projects for the Villa Baizeau, at Carthage, a suburb of Tunis (1928).[12] Although the client rejected this idea, it reemerged in the Ahmedabad house designs, eventually constructed as the Villa Shodan (1951).

Fig. 4
An example of Le Corbusier's later approach to the window in the maisons Jaoul, Paris, 1951–55. © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC. Photo: author.

In this house, combining *brise soleil*s for shade, an open plan for ventilation, and a carefully controlled series of openings, closures, and ventilating slots, the glass wall arrived at its unlikely conclusion.

Le Corbusier's article for *Tchéco-Verre* drew heavily on earlier pieces he had written about the use of glass and on the Salvation Army hostel. Despite the disappointments of the Centrosoyus and Salvation Army hostel, the tone is indefatigably upbeat. The typescript draft for the article, marked up with a few corrections, is conserved in the archive of the Fondation Le Corbusier, Paris.[13] The correction of a number of homonyms (for example, *masses* was changed to *masques*, *bois* to *poids*) and some repetition suggest that the text was dictated. Compared with the chapter on exact respiration in *La Ville radieuse*, this essay is more discursive and less heavily supported by quotations, illustrations, and statistics. It marks an important moment in the coming of age of modernism, when one of its fathers struggled to come to terms with the complexities of carrying out the logical consequences of structural rationalism and the search for transparency.

—Tim Benton

Notes

1 Le Corbusier, *Toward an Architecture*, 102. This sentence first appeared in the article titled "Trois rappels à MM les architects," in *L'Esprit Nouveau* 1 (October 1920): 92. This article formed the second chapter of the book *Vers une architecture* (Paris: G. Crès et Cie, 1923).

2 Le Corbusier, "Notes à la suite," 46.

3 Moholy-Nagy and Hoffmann, *The New Vision*, and Giedion, *Building in France*.

4 Le Braz, "La transmission de la chaleur à travers le verre," 12–18.

5 "J'abrège: Le verdict est celui-ci: Le principe dit de 'la respiration exacte et des murs neutralisants' est de l'ordre des choses pratiques" (Le Corbusier, "Discours d'Athènes," 81–89).

6 Le Braz, "La respiration exacte," 90–92, and Le Braz, "La transmission de la chaleur à travers le verre," 12–18.

7 Le Corbusier, "La Cité de Refuge de l'Armée du Salut à Paris," 17–19.

8 Ducret, "La Cité de Refuge de l'Armée du Salut à Paris," 23–29. R. L., writing in the August–September 1932 edition of *Glaces et Verres*, was disappointed to note the abandonment of the double glass wall and the system of *respiration exacte* (10–12).

9 Taylor, *La Cité de Refuge de Le Corbusier*, 102–3. One of the entrepreneurs, Sulzer, quoted 1,640,000 francs for a mixed system of radiators and pumped hot air, adding 870,000 francs for a system of refrigeration—this for a building whose total cost had been estimated at 4–5 million francs.

10 Le Corbusier, *La Ville radieuse*, 44.

11 Ibid. See also Le Corbusier, *The Radiant City*.

12 Benton, "La Matita del cliente," 17–24.

13 Fondation Le Corbusier, A3(2)294, Paris.

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R. L. "La Maison de verre de MM Le Corbusier et Jeanneret, et le mur neutralisant—Cité du Refuge de l'Armee du Salut." *Glaces et Verres* 29 (August–September 1932): 10–12.

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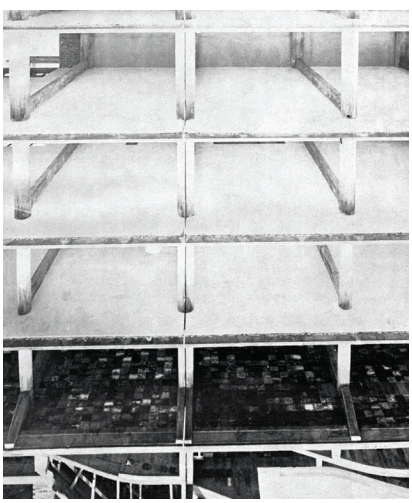
Glass, the Fundamental Material of Modern Architecture

I.

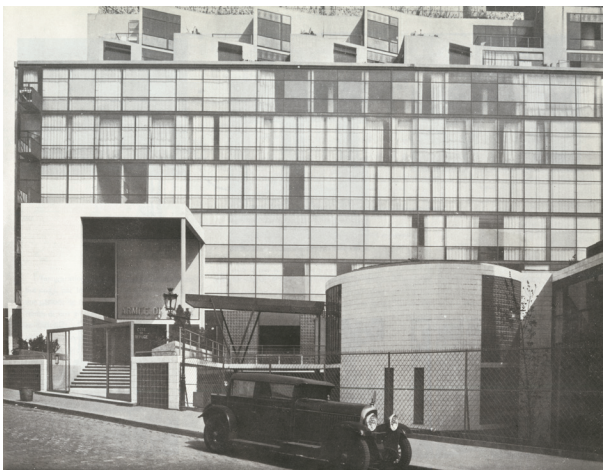
One hundred years, representing the first machine age, has just passed, during which research into countless new techniques has given rise to so many new methods and new consumer goods that traditional society has been disrupted and is now in urgent need of reform. This new period is the second machine age: indeed, it is a new era of machine civilization. But this is not the place to develop this theme.

Returning to architecture and urbanism, however, which is a direct extension of this, I can state that glass will be a characteristic feature of building in the new machine age because it is the most direct means by which we can find one of the essential conditions for life: sun and light. The second machine age will be responsible for restoring mankind to a harmonious relationship with nature, and with the human and the cosmic. The first machine age (1830–1930) had torn this apart.

Glass is the most miraculous means of restoring the law of the sun.



The reinforced concrete structure of the Cité de Refuge during construction. © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC.



The Cité de Refuge, the Salvation Army hostel on rue Cantagrel, Paris, soon after completion in 1933.

II.

The history of architecture in temperate regions is, we can say, the story of the conquest of light. A hard and ongoing struggle between conflicting functions: one, the wall, designed to support the house (and it is essential that the wall is as solid as possible); the other, the window, to illuminate the house (yet the window tends to destroy the strength of the wall). Thus, over the centuries, it has been a struggle between two opposing functions, and progress has been almost imperceptible because the latest construction methods for stone, combined with wood or iron, these methods persist; that is to say, the wall still supports the floors of the house.

Steel appears in the nineteenth century, reinforced concrete in the late nineteenth century. Suddenly, through the development of new technology, we see that the floors need no longer be supported by the walls, but by small posts or columns placed inside the house. We realize that it is unnecessary to construct walls from the ground up or to make the facades stand in front of concrete and steel frames. This revolution is important, but we have made little progress from there on; the viewpoint of the Academy is rampant everywhere. They still insist on "drawing" facades. These facades are only masks. But this is the turning point. How difficult it is for architects, especially teachers, to abandon completely the traditional concept of the facade, to even begin to discover something else. So we persist in misunderstanding current practice by

building stone masks in front of these magnificent steel or concrete structures, fully open—100 percent—on all sides, to the light. This costs us considerable amounts of money, and urban residents in their homes or offices still do not receive the supply of light that they need and deserve. The Academies continue to reign with all their lies and stupidity. One great day this will all collapse; enough lessons and proof have been handed down by our forerunners. They now seek, in all honesty, the healthy expression of a modern architecture. One day the "glass wall" will become obvious, and we will not have to discuss it further. But first, there must be a sufficient number of people with the advantage of these insights to make it better known and recognized: The "glass wall" is the conquest of the Modern Age. The walls do not have to support the floors: on the contrary, each floor, quite simply, carries its own level of glass, the weight of which is no longer part of the construction material. The liberation is complete. Once more, this is the great architectural revolution.

III.

Here is the maximum light entering the house, the office, or the workshop: it is 100 percent.

But it raises the question of how to deal with this new breakthrough, which is not without major obstacles, and poses questions that remain to be solved by technicians and specialists in various fields.

In fact, new problems arise which are important:

A the problem of cold behind the glass wall,

B the problem of heat behind the glass wall,

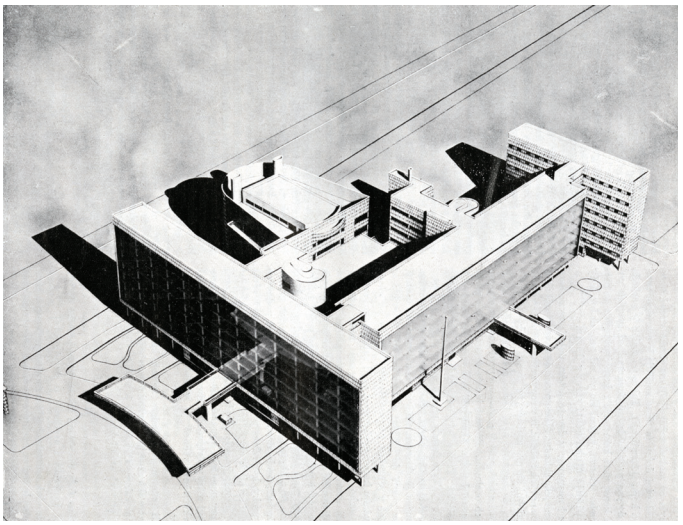
C the glare behind the glass wall,

D the cleaning of the glass surface,

E the requirements of comfort at certain times of day,

F the problem of aesthetics in general.

Thus, research continues.



Rendering of the Centrosoyuz building in Moscow, 1928. © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC.

IV.

But, before facing these new challenges and beginning the search for desirable solutions, it would be useful to see without delay what the new glass wall is like, and whether it is sufficiently convincing to encourage us to pursue research into related solutions. If the glass wall were only a technical achievement that confronted mankind with a new disorder, it might be better not to continue in this spirit of expectant discovery. But if, on the other hand, the glass wall satisfies the essential needs of human nature, carrying with it the possibility of multiple architectural solutions—diverse, flexible, varied, and enjoyable—then we would feel especially encouraged that it is our duty to pursue the path of discovery.

What exactly is this "glass wall"?

From story to story, the floors are spread out like playing cards arranged horizontally on needles or wire mesh as represented here, although in reality, on a steel or concrete column. What was once a facade or supporting wall no longer exists; it is a huge opening that can be closed against the elements and against thieves.

This enclosure, like factories made of modern materials, will be formed of a rigid lattice of iron, concrete, or even wood, fitted with its mesh of translucent or transparent materials: glass.

So, already, here are three entirely different aspects to the outer skin of the house, which can be made of iron or concrete or wood. And similarly, each of these approaches has a great range in application, depending on the choice of vitrified materials designed to fill the space between the floors.

This, therefore, offers a whole new set of combinations.

In addition, within the rigid steel or concrete lattice supporting the vitrified materials, there is nothing to prevent us from combining elements of stone designed to reduce the extent of the glazing (e.g., as in large areas of our recent project for the Musées à Paris).[1]

This shows that the architect can even incorporate in his research countless combinations that are fundamentally architectural. As a result, people who obstinately cry scandal against us merely tie the Academy up in knots by the emptiness of their protests, shouting uselessly and without any valid reason. Architects will work—these creators, visionaries—who will erect new facades as eloquent as the old ones. The beauty of a facade does not lie in the subordination to a classic style, but is the result simply of an eloquent sensibility and a critical sense of proportion.

Nevertheless, there is still much scope for introducing a wealth of new plastic resources to architecture. In fact, the vitrified materials to be used will play a decisive role, seen from the interior, participating in the domestic symphony and the everyday joys that the home can give, by a multiplicity of industrially produced effects that already exist, and that could be further developed greatly once the program is clarified.

The existing vitrified materials available are:

1 Transparent (glass, plate glass).

2 Translucent, that is to say, one cannot see through them and yet they are endowed with varying degrees of light penetration. Countless methods

exist in the manufacture of vitrified translucent materials (some that are admirable, and some that are ugly).

3 The combination of one and the other, which, according to nuanced reports, offers thousands of judicious combinations.

4 This new wall of light, constituting the fourth wall of the room, can be used architecturally with all the necessary grace and imagination, becoming a "useful wall" (*mur employable*), that is to say, a wall that can include built-in furniture and bring about this miracle of the Modern Age: the four walls of the room can be utilized. It should be noted that, in the current state of architecture with stone or brick facades, the fourth wall, with a side window, is virtually unemployable, formed as it is of illuminated areas in which the piers cast strong shadows. Shade is the enemy of man. An area that has a bit of shade is an area diminished.

5 The glass wall could not truly enter into the consideration of innovative architects until now because the manufacture of glass has undergone fundamental changes in only the past thirty years. It is important to remember that the period of the Sun King, Louis XIV, eager to reflect his splendor and power, had only extremely limited glass surfaces, generally not exceeding one meter in size. The Hall of Mirrors at Versailles proves this.

Modern technology has provided the building with an exceptionally beautiful product that is, it may even be said, miraculously beautiful because it is theoretically perfect: this is plate glass. Glass that allows total light penetration, passing through without any distortion. Glass that, from inside the building, is as pure as a clear sky and that, from outside, provides distinct angles, a sense of flow, brilliance, and fluid movement. Glass that gives a sense of perfection. What a wonderful material to perfectly express part of the spirit of the Modern Age!

Now glass technicians have found the means by which this newly achieved elegance could be sold at a reduced price. In recent years they have discovered thick drawn glass that is transparent. These forms of glass do not have the impeccable quality of plate glass, but, in practical terms, they are almost equally employable, and this is a significant breakthrough.

Le Corbusier's apartment at the Immeuble Porte Molitor, an eight-story apartment building designed by himself and Pierre Jeanneret on the rue Nungesser et Coli, Paris, 1933.

Having to realize the great glass wall of one thousand square meters at the Cité de Refuge,[2] we did not hesitate to use drawn glass, instead of plate glass: this decision allowed us to make significant subdivisions of the glass surface without having to strengthen it with iron glazing bars.

Whether using plate glass or drawn glass, the architect can now deal with unified surfaces, as in true architecture, and by using this material he has achieved a new element of grandeur.

In plate glass, if only clear glass is employed, the results can sometimes be irritating, sometimes consistent. Our concern here with the inhabitants of the house is divided between contradictory alternatives: that of the pleasure in seeing the play of the sky, trees, or general views outside, and secondly, that desire to be secluded from the outside and especially to have some privacy. It is here that combinations of translucent glass and clear glass can be involved and that the role of the creative imagination can be manifested.

The possibilities of translucent glass are endless. They even have some important intrinsic virtues: for example, prismatic glass—Luxfer or diamanté glass[3]—whose effect is to completely break up the sun's rays and distribute them in the interior, as a shower divides the water into innumerable droplets. This simple scientific phenomenon can make a decisive contribution to architectural design. For example, I was called upon recently to build a painter's studio in a building so organized that it was impossible to install a window facing north. But the requirement to face north has, thus far, always been the rule imposed

on any painter's studio. Why north? Simply because direct sunlight should not be introduced, as it brings an intensity of light and localized effects that disrupt the painter's keen appreciation of colors and values. Since I could not install glazing to the north in this studio, I had the idea of building "glass walls" to both east and west fitted with prismatic diamanté glass. The sun, therefore, is overcome; its direct rays do not pass through but, broken into countless beams, they reconstitute the calm and regular atmosphere desired by all painters. A considerable gain: this light, instead of being cold, was warm and bright, and the studio, instead of being like a cellar, has become a place full of charm and radiance, one could even say, joyful light. Thus, the introduction of prismatic glass overcomes such traditional practicalities: a painter's studio no longer needs to be facing north.

Such experience is important when it arises, as is the case this time in Paris in building the Musées de Peinture (Musée de la ville et de l'état). The mediocre solutions or feats of strength that were needed to introduce a steady light into the galleries are now replaced by effective means: the architect has acquired considerable freedom. Architects have not yet grasped clearly that they have these miraculous means at their disposal.

Apart from prismatic glass, which has thin lenses, the industry offers vitrified materials for architecture that are thick, massive, or concave, similar to sealed bottles. Cast glass bricks are a valuable resource; they have huge strength in resisting impact and have great powers of insulation. Very interesting lighting effects have been obtained from these "Nevada bricks" due to the profile of their front face. But one can also create blocks from blown glass, bricks in a prismatic shape like sealed bottles, which also have great insulating power and excellent light diffusion.

Several years ago, we proposed a process to the Laboratoires de Saint-Gobain, which is currently under review and will be finalized soon: it is the manufacture of large slabs of glass, up to several centimeters thick, made of glass foam. Architects will then have a strong material that looks very firm, that will be translucent without being transparent, that will have powers of insulation, and that will be an outright replacement for a thick wall of brick or stone.

The door remains open to all in industrial research, from the moment the fourth wall of the room becomes a glass surface, and from the moment one renounces stone facades, the enemies of light.

Finally, it remains for us to pose the problem of architectural aesthetics. If the introduction of the glass wall to domestic architecture had the effect of giving the house a forbidding aspect; if the use of the glass wall was opposed to all plastic expression, or could interrupt these multiple combinations of proportions, I would not hesitate to say that this whole field of experiment should be suspended and that the architect should wait for new research to bear fruit: that fruit being to open wide the door to architectural creativity, that is to say, toward the emergence of aesthetic pleasure. For several years we tried to suggest that the new architecture did not have to worry about questions of art, and that all that was useful was sufficient in itself. I never accepted this premise, and always asked the architect for an affirmative commitment to create works of volumetric beauty; plastic beauty is a reality as imperative as technical efficiency, and the human heart with these aspirations toward harmony is the essence of the architect's nature.

We can be reassured: the glass wall, as I mentioned above, is available to all plastic creations, and with limitless variety. But what I want to say here is that the introduction of glass into contemporary architecture as a fundamental material brings a clarity, a sharpness, a sort of absolute potential of architectural combinations that are realized for our pleasure and, in my view, express one of the essential characteristics of the machine age: purity. Purity, based on contemporary aesthetics! This assertion is equal to any other; in fact, I think it is superior to many of the others.

While we are speaking of aesthetics, I feel that at this point we have to pose a question: Can that which may be perfectly suitable for a home, a small home or a rented apartment, cope with the architectural demands of monumentality required in the construction of what is still known as a "Palais"? A few years ago this question was still awaiting an answer. I personally found myself facing this tough question: "How to confer on buildings that seek to attain nobility, the character of permanence and of sufficient monumentality?" This is the concern surrounding the construction of the Palais des Nations in Geneva.[4] At that point, nothing had been done in this direction. It was only after many weeks of anxiety and deep thought that I realized one day, quite naturally, that a Palais can find its monumental expression by two inseparable circumstances: the creation of an internal organicism, living, throbbing with life, and its opening to the outside world by means of windows or glass panels. I then considered that, from personal experience, here as elsewhere, there was a single problem: a problem of plasticity, a problem of visual art. How can

we solve such a problem? Like all works that embody human lyricism (poetry, music, sculpture, and painting), we find a symphony of plastic elements that play against each other by their similarities and contrasts, according to mathematical laws that govern human creation as they govern natural creation, real checks and balances in power relations. Let's not mince our words: architecture is a manifestation of human lyricism; this occurs only by the quality of the intention and the purity of the relationships that have been brought into combination. There is no need for unnecessary or superfluous display, no need for the usual academic additions: pediments, statues, friezes, etc. The architectural spirit is manifested by the mass of prisms that rise up into the light, and the quality of the relationships between them. A home can be a palace just as I can say that a palace should be a home; that is to say, a palace should first serve specific functions and only then respond to the final aim of architecture: to move or provoke.

A question was raised recently in Rome by the president of Syndicats d'Architecture, who was very concerned about the policy that should be adopted regarding the construction of the Palazzo Littorio, facing the Basilica of Constantine and in front of the Colosseum on the Via Imperiale.[5] I answered: "For me, there is no doubt. To adopt any conceivable language when confronting the stones of ancient Rome, there is only one possibility: iron and glass—these two materials are products of intensely modern technology. Because," I asked, "what constitutes the unity between various works, created under different civilizations, climates, or different centuries? It is the potential for creative energy. This is where the unity lies; this is the point where the potential of invention is of the same intensity as the functional unity. The whole history of architecture shows us this. All the great cities of the past demonstrate it repeatedly. Works that normally co-exist well are not necessarily those of the same style, but those that have the same creative power in the depths of themselves." And I concluded with this: "Do not think that it can be achieved by imitating the forms of the Colosseum, or that by employing the same stone as the Colosseum, today in 1934, you will obtain unity. You will display merely the falseness of it, and it will be a miserable failure."

V.

I said at the beginning of these notes that the use of the glass wall posed new technical problems of capital importance. I will outline them, one after the other:

A and **B** The cold and the heat. The glass wall is a universal technique and the sun is a universal requirement in all climates, in all latitudes, under all solar systems. Whether in Buenos Aires, North Africa, Paris, Berlin, or Moscow, there will always be in the buildings of mankind, behind walls of glass or stone, those who wish to have sunlight. The glass wall fully meets this need, but, according to the latitude and climate, the effects are different: in Moscow, where the cold reaches −40°C in winter, a simple piece of glass will cause intolerable discomfort. In Algiers, according to its orientation, the glass wall will introduce sunlight in such abundance that it will produce unbearably high temperatures: the discomfort will be dangerous. And so on.

So these are problems of cold and heat. And the solution cannot be achieved by separation of these difficulties, but rather, by their synthesis.

We must reduce this problem to its fundamentals, which is purely and simply a question of the lungs. The human lung must be supplied with air temperatures approaching 18°C and a humidity quite clearly determinable according to the seasons and climates.

If one attempts to feed the human lung air to breathe, the same solution is valid in both Moscow and Rio de Janeiro. But in Moscow, as in Rio de Janeiro, new difficulties arise: it is a problem of a different kind: the intensity of light acceptable in Moscow is unacceptable in Rio de Janeiro.

To settle the question of the lungs, modern technology offers compelling and flawless solutions already tested in a thousand places; but it has a strong impact upon people's sensitivity, and provokes childish psychological reactions. The solution is to install in any inhabited space a system of air conditioning by permanent circulation, the environment to be fed constantly with fresh air, living air. This air is produced by a thermal power plant in summer and winter. The means exist that meet the diverse needs of the climate. I cannot explain them here for lack of space, but I am so convinced of the need to arrive at synthetic solutions that in the book I have currently in press, dedicated to "La Ville radieuse" (about how to equip towns, villages, and farms in the new machine age), I have devoted a chapter to explaining "exact respiration" (*respiration exacte*), which I have designated as the cornerstone of any modern urban development.

As the specialists who read this article already know, research throughout the entire world converges increasingly toward the same goal, which is to provide

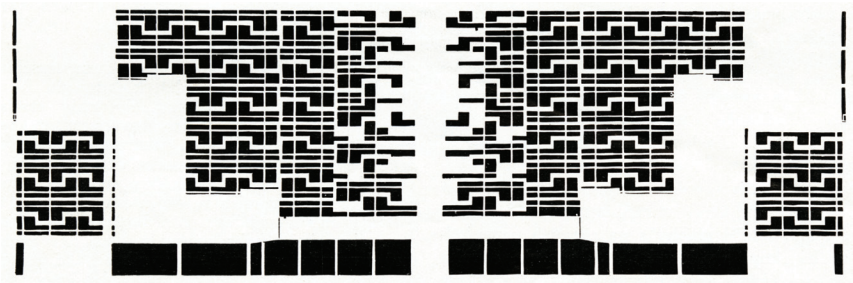


Diagram of the glazing on the facade of Le Corbusier and Pierre Jeanneret's competition entry for the Musées de l'État, 1934–35. © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC.

the human lung with a regular supply of air. The consequence of the application of this rational method will be unexpected in terms of architecture. This system will encourage the construction of facades sealed with glass panels, so as not to allow air from outside directly into the house, but only a single source of air prepared in good conditions, drawn from outside of course, but "conditioned," as its name suggests.

Very simple methods of natural cooling will allow this relatively fresh air to circulate in the interior spaces during high summer. What will be decisive will be the presence of mobile air, lively, in movement, unlike the current practice which is content to admit stagnant air, the source of all ailments during the summer (and winter too).

In midsummer, whether one is in Moscow, Paris, or Rio de Janeiro, the town dweller may find himself behind a glass wall bathed in sunshine without suffering any inconvenience. His lungs will be filled with air at 18°C and he will be placed, more or less, under the conditions of a tourist in high mountains or as a bather at the beach by the ocean.

c The glare. This is simply a matter of technique and a good problem to have. But first of all we must sort out some errors of judgment: it is argued that in hot countries, the small window is essential to avoid glare. This is absolutely false. The small window pierced through a solid wall, letting in the sun, is like a cannon shot whose effect is to tire the retina and cause a real malaise.

Let's look at things properly: imagine you are in Rome, for example, in the summer. You are in a trattoria or a house where the sunlight enters through

small windows. The room is black (dark), the beam of the sun is like a cannon shot. This is overwhelming! Go out into the street: if you are on the sunny side, of course it's too hot. Take ten steps, you are on the shady side. You're comfortable. Your eyes have calmed down if you look into the shaded houses or ahead of you. Yet you have upon you all the light from the sky—100 percent light. Are you not in the same conditions inside a house behind a glass wall? The light that floods a room is not exhausting, but the light that enters through a basement window is oppressive.

However you choose to live, there are still many ways to find shade. I explain it by this simple term: the glass wall can be, and should be, controlled with adjustable shutters (*diaphragmé*) inside the glass envelope. Various methods exist that are more or less effective. First of all, venetian blinds were certainly not invented for glass walls but can be applied to them quite effectively. We have used shutters behind two large glass walls (at the Cité Universitaire and the Salvation Army). These are installed in the interior and deploy to the left and right (remember that we decided upon a current of fresh air passing through the living space, therefore the warming of the interior shutters by sunlight does not matter).

But it is possible to create screens behind the glass wall that can be moved at will and which, under normal conditions, in winter, for example, occupy a third of the glass panel. Those same screens deployed in the summer can block the glass panel completely or can be left to filter the stronger light rays at will: the occupant himself can dispose the screens to his liking.

The glass wall thus implies the need to create effective shutters. Posing the problem brings us toward the solution. If the technologists work hard we will soon have our answer, provided that we accept once and for all the need to separate the issue of the lung from that of the eye, and not confuse everything with dead-end solutions.

VI.

D Cleaning. Cleaning is achieved by a method which is like the egg of Columbus—the solution is simple once you see it. Simply install a rail on top of the building. This rail will support a trolley or gangway projecting in front of the facade, like a small footbridge attached to cables. This trolley will descend from the top to the bottom of the building, or across from left

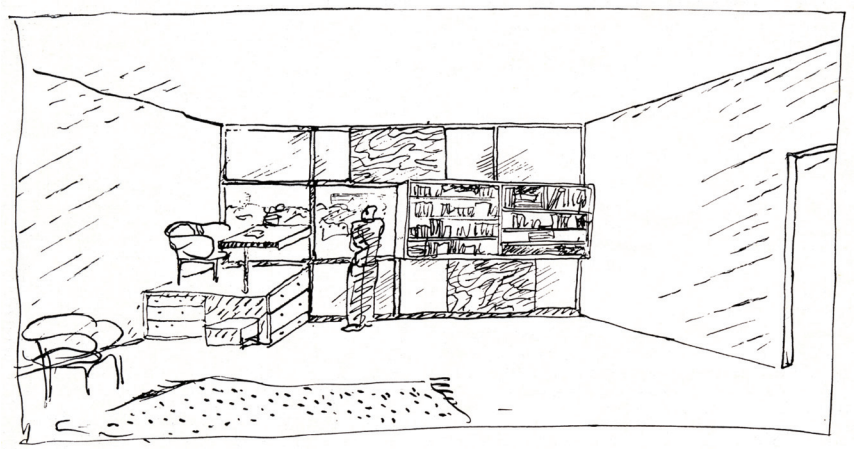
to right. On the trolley one or two men can clean each section and, while whistling and smoking cigarettes, they can do their work with ease without bothering anyone inside the house. We planned this system for the Palais des Nations in 1927. We realized it at the Cité de Refuge, for the Salvation Army. This trolley, installed in a timely manner, allowed for the positioning of the network of iron glazing frames, for the installation of the glass, and for the painting of the facade, and is now in constant use for regular cleaning of the facade. The solution is extremely economical, in terms of both costs and scheduling.

E It remains to sort out a sensitive matter, that is, to overcome the unpleasant impression of a large window open at night to the outside. Any glass surface from the interior appears as a black hole. Some prismatic or strengthened glasses are less offensive than transparent glass. A new Italian invention, Thermolux glass, designed to remove the effect of intense sunlight in hot countries and possessing insulating properties, also has the ability to appear like a fine tissue paper with a whitish or pale pink hue at night when the lights are on inside. The glass wall then resumes a particular eloquence: it becomes a white wall at night, so that the feeling of anxiety is replaced by a sense of tranquility. This demonstrates that architects can focus on the solution to the problem and provide an answer.

F Let us end with the question of aesthetics in general, although I anticipated this point in the preceding pages.

I want to make it clear that glass implies a new concept of architecture because its appearance is absolutely new, something that never existed in previous ages. Glass therefore results in a new architectural sensibility. We have seen above that it would be seriously inconsistent to attempt to deny the importance of glass for reasons of aesthetic habit, since glass today provides us with the solution to the problem of sunlight.

The discovery of electric light and its prodigious application in less than twenty years has also introduced a new phase in the life of contemporary society: that is, nightlife. Nightlife is quite brilliantly illuminated by the radiation of sparkling and joyous electric light. Men have begun to live by night as well as by day. Are they right? I do not know, but it is certain that a huge part of family life, in particular, is now passed under floods of electric light.



Le Corbusier's drawing of an interior demonstrating the increased flexibility of useful space as a result of the "glass wall." © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FLC.

The lyricism that attaches to light, whether sunlight or artificial light, is always an important element to consider in relation to architecture. The stage is set for poets, just as it is for technicians.

* * *

Is it possible to accept that glass, this inconsistent material, can form the basis of modern architecture, that is to say, a sufficient support for plastic phenomena developed in space under the effect of sunlight?

I would not want to answer this question in theoretical terms alone, because I would feel uneasy. But these recent years of practice have given me the opportunity to go further into the full extent of the problems raised by this question, problems considered here, at this time, exclusively on the volumetric side.

In 1931–32, we had the opportunity to prepare extensive plans for the construction of the Palace of the Soviets in Moscow.[6] This palace crowned the Five Year Plan and responded to an immense program, closely related to the new life of contemporary society. Alas! the project has since changed its face, and the Soviets are currently building a gigantic wedding cake, 480 meters high, which is more like the cake of Princess Marina than a work of contemporary architecture.[7]

In the research we've undertaken on this palace, we had reached a synthetic solution that made glass the fundamental element of this construction. All the problems were settled at a stroke: at one and the same time, the problems of sunlight, artificial light, of heating and ventilation. And, remarkably, in this palace that included countless services, and diverse spaces ranging from gigantic halls for fifteen thousand listeners to small offices for staff, by using a single element of glass we could meet all its requirements. This element of glass took the form of large bricks or slabs composed of two glass surfaces translucent or transparent (plate glass or reinforced glass or poured slabs, as appropriate) placed ten centimeters from each other and enclosed by a crimped iron frame. This slab was sealed: it occupied the full height from floor to floor, that is to say, four meters in this case; its width was one meter ten centimeters. These giant slabs were interspersed between floors, with sharp joints, one against the other. They were thus the facings of the main building, whether in the great hall for fifteen thousand people, or the administration, or locker rooms, or library, or theater, etc. If you feel that one could cry out from the monotony! Please look at Versailles and the Invalides, or at any work of architectural splendor. You will note that the element of glass is always there. Its scale was generally up to the very limit that could possibly be achieved at the time. This uniformity is precisely one of the essential factors of unity.

Moreover, the method that we used for the Palace of the Soviets was really a characteristic type of jointed facing, of an agreed proportion, constituting a method similar to that allowed in all periods for the alignment of blocks of marble or stone.

Inside these giant glass slabs was installed an electrical resistance which allowed for the adjustment of the heat in the vacuum between the two plates of glass; the "neutralizing wall" was thus created.

Furthermore, the tubing for neon lighting was housed inside the glass slabs, providing a light source at night similar to that of sunlight. What a beautiful effect, from the inside as well as the outside!

Unity is therefore provided by the glazing, and architectural diversity will be a result of these designed forms, from the harmonious combination of load-bearing structures and in-filled dividing walls. There is no reason why the architectural symphony should not be fully primed and ready. On the contrary, the information that we now have is of a clarity and wealth hitherto unknown:

the tension of the structural frames, amplitude of the volumes, brilliance of the glazed materials.

* * *

Come on, then! Architecture does not die because new methods are born! On the contrary, architecture is reborn even greater because of the admirable riches brought by modern techniques invented during the nineteenth and twentieth centuries.
■

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1 The competition for the Palais des Musées d'art moderne that Le Corbusier had entered in 1934–35. The competition was won by a group consisting of Jean-Claude Dondel, André Aubert, Paul Viard, and Marcel Dastugue, whose Palais de Tokyo was opened for the Exposition Universelle in 1937.

2 The Salvation Army building on rue Cantagrel in Paris, by Le Corbusier and Pierre Jeanneret, commissioned in 1929 and opened in 1933.

3 A type of glass tile with a prism to the rear side that redirected the sunlight from the window to various parts of the interior. Developed by the Radiating Light Company in 1896 (renamed the Luxfer Prism Company), this type of glazing was used extensively on factory and commercial premises. Frank Lloyd Wright designed some of the company's "Iridian" prism tiles.

4 Le Corbusier and Pierre Jeanneret were among the 377 entrants in the 1927 competition to design the new Palais des Nations in Geneva to house the League of Nations. Le Corbusier claimed that the jury recommended his design, but the commission was awarded to a group of five other architects.

5 There were two competitions (1934–35 and 1936–37) for this palace, which would have combined the functions of party headquarters, museum, and residence for Mussolini. The building, now known as the Palazzo della Farnesina, on the site of the Foro Italico, was designed by the winners of the second competition (Enrico del Debbio, Arnaldo Foschini, and Ballio Morpurgo) and completed after the war. Le Corbusier's description of the original site is misleading. It was opposite the Basilica of Maxentius, not Constantine, on the via dei Fori Imperiali.

6 Five successive competitions were held in 1931–32 to design the Palace of the Soviets in Moscow. The competition was won by Boris Iofan, although the building was never completed.

7 Princess Marina of Greece and Denmark married the Duke of Kent in London on November 29, 1934. The five-tiered wedding cake attracted a lot of publicity.