Transparent and Translucent Surfaces of Italian Architecture in the Thirties of XX Century

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ABSTRACT: In Italy between the two World Wars, transparent and translucent surfaces became widespread in architecture, especially in the façades of buildings. The reasons lay not only in the new architectural vocabulary, but also economic, political and technical factors. The demand for transparent surfaces of larger dimensions led to new problems concerning safety, thermal insulation, the diffusion of light and the cost of glass-based materials. To meet these needs Italian manufacturers sought new materials (patents) and mechanical systems for producing sheet glass. In analyzing the characteristics of these new kinds of glass products, very different from those used nowadays, the main sources are international technical reviews and literature, and the archives of the major Italian glass manufacturers of the period. The aim of this analysis therefore is to understand not only the peculiar features of glass products in the thirties but also the meanings underlying the use of a material which in those years symbolized "modernity" in much the same way as reinforced concrete and metal.

INSTRUCTION

"Great apertures, great strip windows, whole walls of glass! Beautiful, often easy to dream about on paper and in ultra- modern projects. But what difficulties you all too often encounter in building these magnificent voids!" wrote Gaetano Minnucci in *Domus* in 1933.

When we talk of materials, glass, together with reinforced concrete and steel, is always associated with a conception of modernity. Glass was definitely one of the protagonists of the development of the new architectural languages precisely because of its transparency and translucence, which virtually evoked the intangible and was a symbol of innovation in those years. It was related to the dematerialization of the masonry envelope, the introduction of the independent static framework and new methods of construction. Increasing the dimensions of the transparent surfaces altered the relationship between interior and exterior, between closed and open, between void and solid. In doing this, it created a different conception of space which inevitably led to the development of new principles of composition. What were the materials of "modern" Italian architecture? The question was raised by many leading participants in the architectural debate of the thirties, and the answers they gave, or sought to give, were complex and at times confused. This was due to the fact that the subject entailed an inevitable discussion of the concept of architecture itself. Polemics, replies and rebuttals published in the various journals made the arguments lively and articulated. Examples were those between Marcello Piacentini and Ojetti and Pagano, or between Edoardo Persico in *Casabella* with Mino Maccardi and Leo Longanesi. Despite the variety of approaches, interest in the subject was widely shared. Sant'Elia, in the 1914 manifesto of Futurist architecture, had already touched on this issue, extolling the use of concrete, iron and glass and various substitutes for wood, while scornfully abusing the use of more traditional materials, which he described as "massive, voluminous, enduring, old-fashioned, expensive". In the fourth article published in the *Rassegna italiana politica letteraria e artistica* in 1927, Gruppo 7 explored this subject, as did Giuseppe Pagano and Marcello Piacentini in various writings between 1930 and 1931. Despite the differences between their general positions, on this topic their views converged. They agreed that it was not the use of materials with innovative or traditional features that determined the outcome of an architectural work. All materials, whether the most innovative like reinforced concrete, iron and glass, or the most traditional like stone, wood or brick become, to quote a metaphor of Pagano's, "words in a poem" depending on the use the architect makes of them. "It is the style that has taken possession of traditional materials and bent them to the forms it ideally pursued; it is the enjoyment of new volumetric proportions that has asked of reinforced concrete all its static possibilities, even at some economic sacrifice; it is the desire for light, air and for new cadences between voids and solids that has given windows a variety of previously unaccustomed forms; it is spirit seeking matter and not matter imposing itself on the architect" (Pagan-Pogatschnig, G., I "materiali" nella nuova architettura, in *La Casa Bella*, 41, May 1931).

FROM CRAFT TO INDUSTRIAL PRODUCTION

Architects did not fail to grasp the importance of materials, either formally or technically. In all the major architectural journals, including *Domus*, *Casabella* and *Architettura*, there began to appear increasing numbers of technical articles, whole features and advertisements which sought to describe the specifications of materials and ways they could be used. This shows the dynamism of Italian industry, with its studies and research in the field of materials. The use of new materials in architecture, and particularly the "glass revolution" which Bardi refers to, was made possible by innovations in Italian industry. The branch of glass manufacturing most relevant to architecture was the production of flat glass and pressed glass blocks. The sector covers a range of very different products: machine-rolled patterned glass, safety glass, plate glass, sheet glass or special patent glass such as Thermolux. Transparent and translucent surfaces of varied thicknesses and specifications divided up the market, from highly specific niche markets to the mass market for window panes. The innovations and changes were so far-reaching that we can speak of a sort of revolution which affected the production of sheet glass and the market for it. This was much more than the discovery of new manufacturing methods, capable of turning out innovative products; it was a transformation affecting the whole sector. The chemistry of glass furnished the instruments and know-how to suggest new uses, identifying the temperatures necessary for their fusion and cooling. Systems were developed to produce new ingredients, such as soda, which gradually replaced sodium sulphate. New equipment and furnaces were introduced to regulate temperatures. To get some idea of the scope of the changes that took place, we can draw on the data published by the Belgian journal "Verre et Silicates Industriels" of December 1939. This showed that down to 1923 in Italy flat glass was produced only by traditional production systems, while by 1940 95% of production was mechanized. By the end of the nineteenth century, in France, Belgium, Germany and the United States, studies had already begun into production systems capable of reducing the labour force through the introduction of machinery. However it took at least thirty years to develop the various industrial patents that followed each other in rapid sequence over the span of a few decades. The main driving force behind research came not from demand in the architectural market, which was not capable of guaranteeing a turnover that would justify the cost of experiments, but from the emerging transport market. Cars, trains, ships and aeroplanes were a continuously expanding market with a strong demand above all for products specifically capable of meeting stringent safety requirements. Immediately after World War I the industry was still based on the traditional method of glassblowing, when it found itself faced with foreign competition on the domestic market. This was both because of the scarcity of output compared with the demand and its poor quality compared with machine-made foreign glass. There was no time for Italian glassworks to adapt slowly; they had to gear up rapidly and install new plant. Factories that had closed were reopened and modernized by introducing the new mechanized or semi-mechanized sytems from Belgium, France and America.

Sheet glass: The revolution in the market for window glass

In the mid-nineteenth an idea was born that revolutionized the production of window glass: this consisted of drawing the panes directly from the pit of molten glass. These methods, after various improvements, proved highly competitive against other methods of producing window panes. The reasons were on the one hand simplicity of management and maintenance, and on the other cheapness. Daily production rose to quantities hitherto unheard of and required a very small labour force. The work of research and development of these systems entailed several decades of experiments before industrial applications were successfully achieved. The inventors of the earliest methods of mechanical production found themselves faced with a fundamental problem, which was that a sheet of glass tends to shrink because of the horizontal surface tensions and the relative fluidity of the vitreous mass. These first attempts failed to guarantee a product of adequate quality. The sheets were opaque, they lacked brilliancy and were of different thicknesses. It was only in the early twentieth century, with the Libbey-Owens, Fourcault and Pittsburgh processes, that the desired results were obtained in terms of both product quality and production times and methods. The commonest method adopted in Italy was the Fourcault system, patented in 1902. Emile Fourcault, assisted by the glass engineer Emile Gobbe, partly drew on Clark's idea of drawing the sheets vertically. His insight, however, was not to draw the glass directly from the pit, but to force it under pressure through an aperture in a floating refractory element. The glass attaches itself to a frame which rises slowly dragging the ribbon of glass behind it, being drawn vertically by a series of rollers and, at the end of the drawing pit, the ribbons are cut to the desired lengths. The composition of the flux for producing sheets of glass drawn using the Fourcault method is similar to other methods for mechanically drawing sheets of window glass. The various components are first ground up and blended mechanically, then transported to the furnaces. To solve the problem of shrinkage of the width of the glass caused by surface tension, Fourcault immersed in the pit of molten glass a refractory block with an aperture, called a *debite*use. This remained almost immersed in the glass. In particular, the two parts with a U-shaped section remained below the level of the pit. When pressure was applied to the debiteuse, which would otherwise float, the molten glass flowed upward through the slot, from the peculiarly-shaped lips of which it is continuously removed by the drawing apparatus. The glass from the debiteuse rises to the height of the steel rollers through a vertical rectangular stand-like structure 4 meters high enclosed by a metal surround to keep out draughts. The panes produced by the Fourcault system were of medium-low quality but well suited to use as window glass. This system of mechanized production ensured that the glass was all of the same thickness and free from bubbles, since it never came into contact with the smoke of the furnace, and that both sides have a good degree of brightness. Its main shortcomings were fundamentally due to the system of production itself. One was that stripes appeared on the surface, being formed when the glass was drawn through the aperture of the debiteuse. Another was controlling the temperature inside the drawing stand, which falls from about 500°C in the proximity of the first rollers to 50°C when the glass emerges. There is a critical zone where glass changes from viscous to solid and it is essential for the temperature to be homogeneous in this zone. This is a difficult operation because it is impossible to control convection currents inside a tower some 4 meters high. This placed certain limitations on production. Glass of greater thicknesses could not be produced because it might be poorly annealed, hence there might be inner tensions that would make it brittle, but above all it would lack the qualities enabling it to compete, even considering its cheapness, with lustre glass.

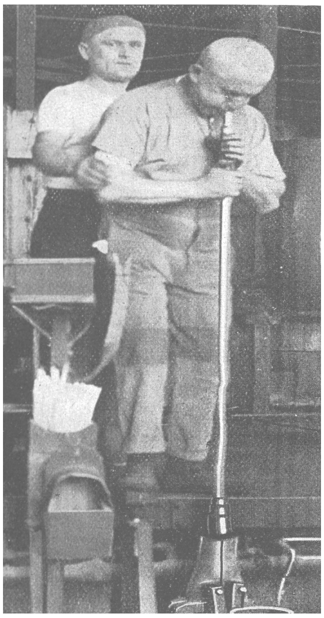
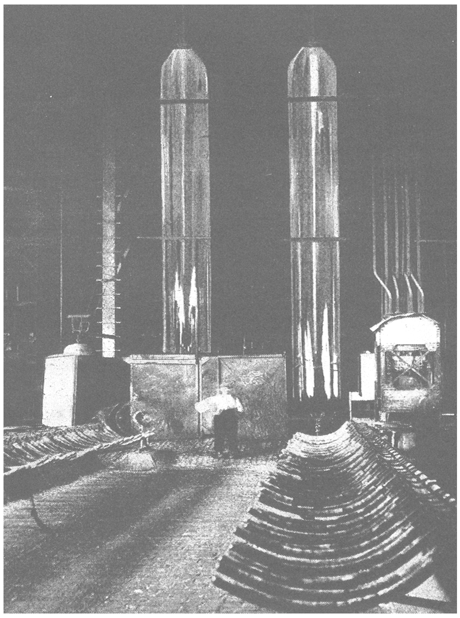

Figure1: Glassblowing (left) and manufacturing with the Lubbers mechanical system (right); (*Glass industry*, 1927)

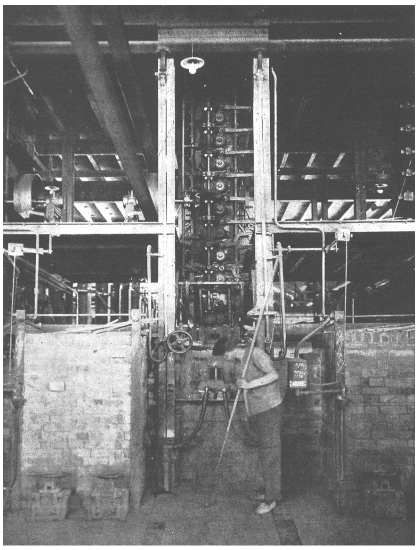
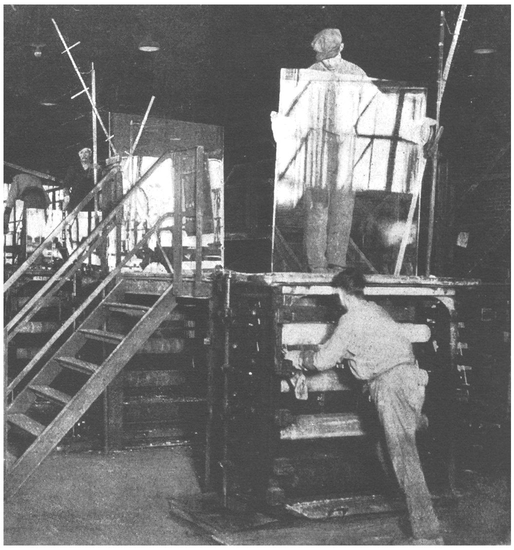

Figure 2: Fourcault Machine; (*Glass et Verres*, 1929)

Machine-rolled patterned glass: Translucence and decoration

Machine-rolled patterned glass, also known as raw glass laminates, are sheets of glass which have decorative patterns impressed on one side. They are not transparent and their translucence more or less evident depending on the ornamental pattern. The process by which they are produced is like that of float glass. The commonest industrial system uses roller printers. The procedure was patented in 1890 by the Chance Brothers of Birmingham, England, and took the name of the Chance machine. It consists of four rollers which are driven by special gears. Two are hollow, water-cooled and serve to laminate the glass, while the other two have the decorative pattern imprinted on it. The glass is poured directly from the furnace onto the cast-iron bed, where it is then laminated. The sheet spreads across the bed, which is set on a trolley and moves at the speed of the rollers to the annealing furnace. Here it is smoothed again to prevent bubbles from forming, and then raised and placed in the furnace. The quality of the glass depends in part on the quality of the printer rollers, which have therefore be handled with great care, especially when being replaced, and stored on special shelves. This system of production can also be continuous. An alteration to the bed furnace enables the glass to be floated without a break, so creating a ribbon of printed glass which enters the annealing furnace directly. This system of making continuous float glass was developed by the French Saint Gobain company and made production far cheaper. The main reason for the spread of this machinery was the roller printers, which are extremely light and can easily be changed. This makes it possible, at reduced costs, to produce a large variety of decorative patterns. *Il Vetro*, the monthly journal of the National Fascist Federation of the Glass Industry, in April 1939 published various examples of printed glass. They were produced using the system of the "laminating cylinder whose surface bears the pattern to be printed in relief." The variety of decorative motifs ranged from floral and symbolic patterns to geometrical figures. One, reflecting the Italian political context, was a patterned glass whose use was restricted to public edifices or authorized organizations known as "Littorio glass" it born the Fascist emblem of the lictor's rods and axe and the Star of Italy alternating in a vertical pattern. It was widely used in architecture, furnishings and the installation of display windows and advertising stands.

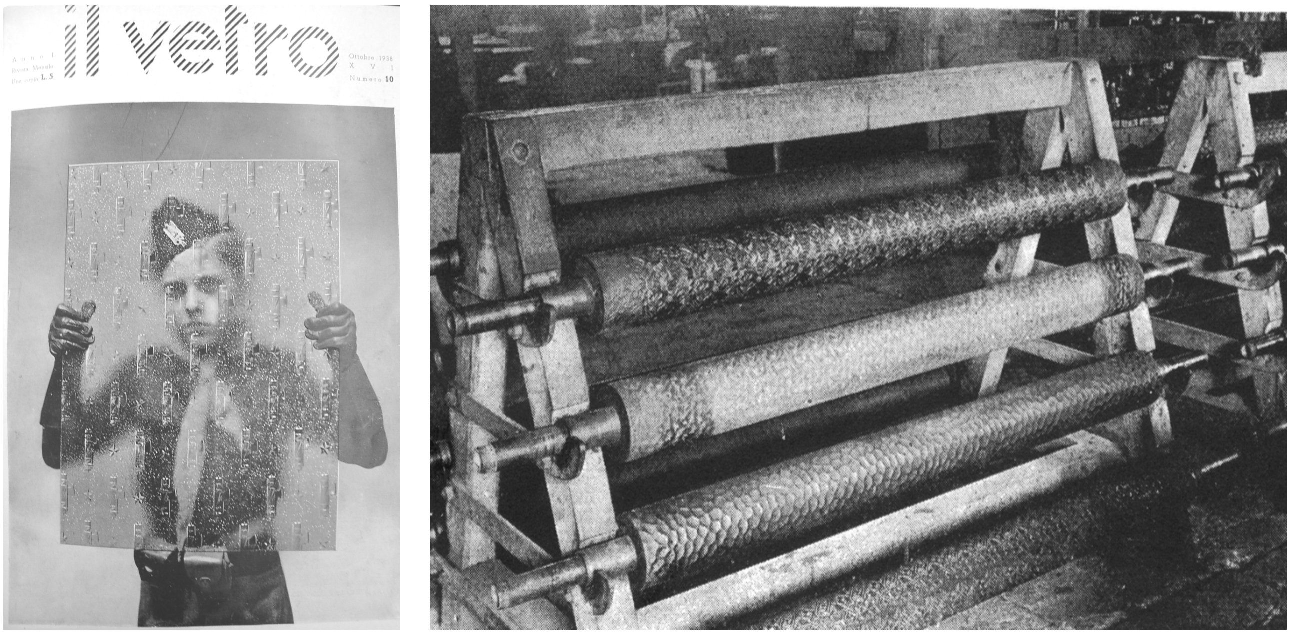

Figure 3: Rollers for the production of patterned glass; (*Il Vetro*, 1938)

Glass and safety

One of the industry's objectives was to overcome the limitations of glass, in particular its brittleness, its inability to resist shocks or support weights and its inelasticity. Above all, the industry sought a way to prevent glass from splintering into dangerously sharp slivers. The quest for a product with these qualities led in different directions and produced layers of glass cemented together, tempered glass and armoured glass. The Figure differences between these types of glass are significant in terms of both production and performance, but they share the quality of being more shockproof than ordinary glass. Often the journals of the period speak improperly of unbreakable glass. These types of glass will in fact break, but only when subjected to forces far superior than ordinary glass. Above all, when they break they do not shatter into sharp slivers. Demand for these products was driven not so much by architecture but by the emerging market for new forms of transport like automobiles, trains, ships and aircraft. Sheets of glass glued together depend on the fusion of glass and a plastic material with qualities such as transparency, elasticity and toughness. It took decades of experiments to move from the conception of this type of product to its production. The result was the first sheets of "sandwich glass", consisting of two panes of plate or crystal glass with a plastic material between them. When these panes break they do not splinter but remain compact. These features are also found in safety glass, but it is not transparent.

Toughened or tempered glass is made of sheets of plate glass or crystal which have been subjected to special treatment, called annealing, so as to acquire qualities of strength and elasticity. When it breaks it does not produce dangerous shards but shatters into small, blunt fragments. This kind of glass is transparent, bright, regular in its colouring and thickness. What has been altered is the inner structure. The journals of the period are rich in images illustrating the specifications of this glass. They show young men and women standing on glass squares which bend beneath their weight without breaking; or sheets shattered with a hammer before their faces leaving them unscathed. Italian manufacturers produced various types of tempered glass: Securit in crystal; VitRex in medium crystal; Temperit in special opaline patterned glass, produced in three basic types, namely patterned on both sides, mono-polished, patterned on one side and polished on the other, and bi-polished, with both sides polished; and Fervetro, a double sheet of with plain surfaces glass made by drawing. These types of glass are used for facades in architecture and in furnishings.
Safety glass, commercially also known as wired glass, is a float glass strengthened by the insertion of wire netting during rolling. It is translucent and it has qualities which guarantee safety in case of breakage, since the wire netting inside it prevents splintering and keeps the pane of glass compact. Experiments with this kind of glass were prolonged, beginning in 1855 with the British manufacturer Newton, who failed to attain practical applications. Subsequently the research was taken up in France in 1886, then in Germany in 1888, but it was only in 1893 with the German Léon Appert and in 1892 with the American Frank Shuman that the results justified experiments in the industrial field. Another reason for the widespread use of this product is the way it behaves in case of fire. Regulations in various European countries have prescribed the use of wired glass for elevator cabins and some insurance companies provide more favourable terms for the owners of buildings where wired glass is used. When the glass is subjected to heat from a naked flame it will crack, but the fragments attached to the wire netting remain compact. The most delicate part of the whole production process is ensuring the correct features of the wire netting. It should not have traces of rust or grease. Even sweat from the hands of workmen may be harmful. It also has to be fitted correctly and with extreme care. If it comes into 1935 contact with the exterior, the process of corrosion will swell its volume, putting pressure on the glass and eventually breaking it. Corrosion can also be triggered if the two slabs of glass are not firmly bonded together. To cope with the problem of corrosion, sometimes chromium-plated iron wire is used. There exist, moreover, two types of safety glass, one with a hexagonal mesh and the other with rectangular mesh. Hexagonal mesh has a grid of about 2 cm and the wires are triple twisted, while rectangular mesh has a grid of about 1 cm and the threads are woven alternately above and below. The wire netting is in annealed soft iron with a grid of 0.5 mm and can be chromium-plated if necessary. Glass with a hexagonal mesh has more uniform resistance, smaller deformability and translucence 17% superior to that of a wired glass with a rectangular mesh.

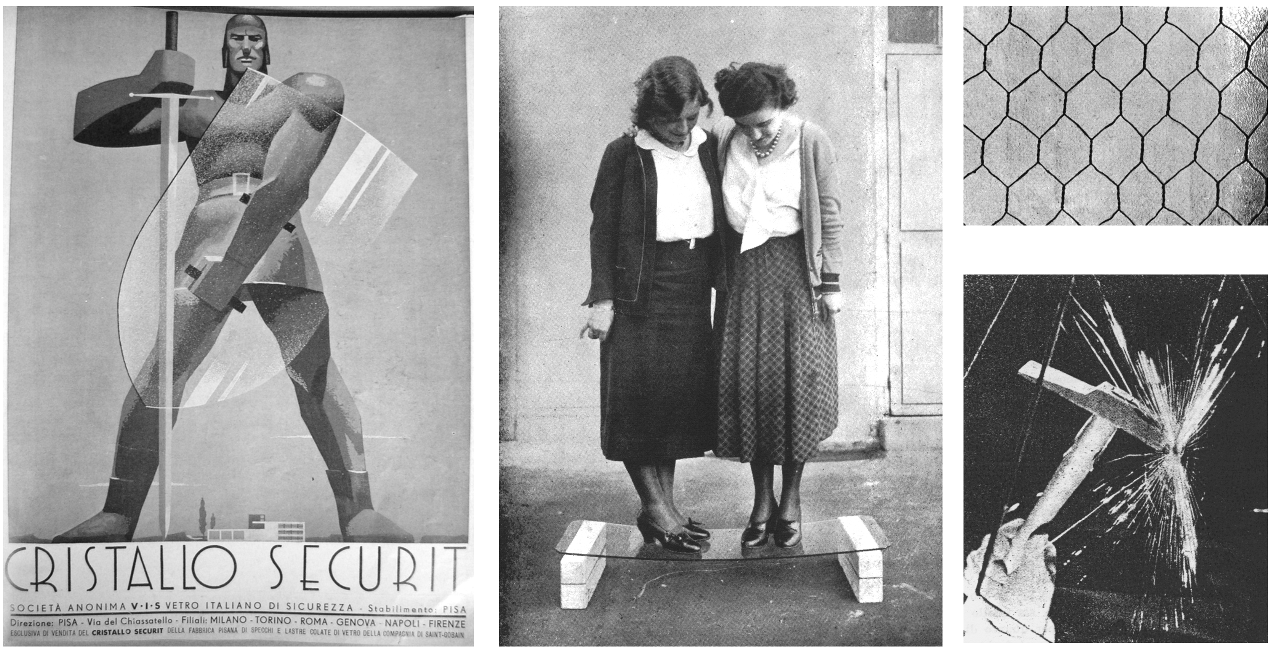

Figure 4: Security safety glass; (*Casabella*, 1938), wired glass; (*Glaces et verres*, 1928) and V.I.S.; (Rovini, 1935)

CONCLUSIONS

Milanese architecture of the thirties used a wide range of glass products in facades, but above all it began to use glass in different ways. This was related on the one hand to the introduction of new architectural languages, and on the other to the availability on the market of products with innovative features, which offered greater scope, and to the decline in costs, with the consequent spread of more traditional products such as flat glass. This research paper attains a precise and in-depth knowledge of the single products. Studies of the mechanization of the methods of manufacturing different types of sheet glass began in Europe and the United

States at the beginning of the century, but it was only on the eve of World War I that they entered industrial production. These products were above all forms of safety glass, which represented the cutting edge of innovation, possessing features that enabled them to overcome the principal defect of glass, its brittleness. Publicity for these products was very widespread, but their use in the architectural field in Italy was limited.
This was probably due on the one hand to economic reasons, on the other to a certain lack of interest in experimental design. As for glued safety glasses in particular, their complete absence from architecture and the very high number of patents that followed each other across the span of thirty years also points to problems in achieving satisfactory quality. Probably they suffered from the failure of the sheets to adhere to each other and the decay of the intermediate layer. Experiments with new architectural languages in the years between the wars were very sketchy; studies of thermal insulation and the diffusion of light were still at an early stage, and the desire to increase glass surfaces only appeared in the work of a small number of architects. Many factors, in these years in Italy, here summarily dealt with, laid the basis for developments that took concrete form only in the fifties: strip facades, thermal insulation, stratified glass. It therefore appears important to stress that these materials, where they are still present because they survived the air raids, wear and tear and change, should be the object of a detailed study before being removed indiscriminately. With their specific features, they represent a plurality of values and are the material record of the industrial, architectural, engineering and social culture of the period between the wars.

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