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From wood to reinforced concrete. Window manufacturing materials in the evolution of construction technology in Italy in the thirties

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The years between World War One and World War Two have been marked by an innovation drive which covered the whole domain of the building industry technology. While the cultural debate focussed on various interpretations of modernity, an unusual interest flared up among designers with regard to buildings technological aspects. The lively research activity entered in those years throughout Europe concerning building materials and technology became intertwined with a broader debate on architecture renewal. In Italy, this took up a trait entirely of its own —the heavy tradition factor bearing down the experimental drive resulting in the uniqueness of the Italian architectural language. New technologies and materials which had just become part of a new building environment were confronted with conventional materials while new uses were being developed for these last.

Trade magazines had accurately underlined new technology research trends since the early Thirties. Many of them devoted extensive space to technical stories and also launched new sections to report on fresh patents for the building industry. Paid space also grew to advertise building materials. A patent number advertised in a magazine would often grant a sort of «added value» to a product as it meant straightforward modernity.

Patents became particularly important in those years. Never before had building designers shown that much interest in patents as such, though they had always»unawares» resorted to inventions in the process of their work. A look at the 1920–40 records of Patent Authority —however peculiar this source may be[1]— shows a special vitality within the building industry. Besides witnessing the experimental climate of those years, this helps clarify the range of relevant research activities in those years (Mornati, 1999a).

Among the various components of a building, window frames are the kind of fixture that makes it possible to verify potential architectural and technological innovation, thanks, among other things, to reinforced concrete frames which by then had become rather largely used by Italian builders, too. In the new structural approach made possible by reinforced concrete, hollow spaces in walls become features of their own as they widen out, thicken or withdraw from the front line, denouncing quite often some new and innovating conceptions of the architectonic body.[2] Such an updating of language, though, calls also for alternate approaches to windows opening, to make large cumbersome wings and shutters more handy and manageable.

Window frames, be they conventional iron or wood, or more up-to-date metallic or concrete ones, will be subject to assiduous and specialised research. In this process, technological innovation will be closely associated with tradition.

Modernization of wooden window frames

In the renovation process of wooden windows, transition to modernity has a lighter hue than in other types of frames. No substantial modifications to frame stress sections, no new materials innovation is strictly confined to the role of windows within the built body and is marked by a will of conserving the familiarly known character which for centuries had been entrusted to wood.

In such limited, though by no means less lively, circle, studies are directed towards possible surface enlargement of windows as well as to making opening operations easier. Also, to suit windows to the new interior spatiality and reduced thickness of curtain walls. From these walls, moreover, windows tend to become autonomous even under a construction point of view. Last but not least, efforts are made towards mass production.

A need for mass production had already surfaced in the early Twenties, since a proposal for an enbloc (fig. 1)[3] window frame is filed with Patent Authority in 1922. Contrasting with the newness of the approach, the pictures show a conventional window frame with a shaped stone edge. The window features also outside blinds and inside shutters. The invention lies in the possibility of disengaging the frame from masonry works as well as in an innovating open-close mechanism as all wings are sliding through a hollow space and can be controlled from inside.

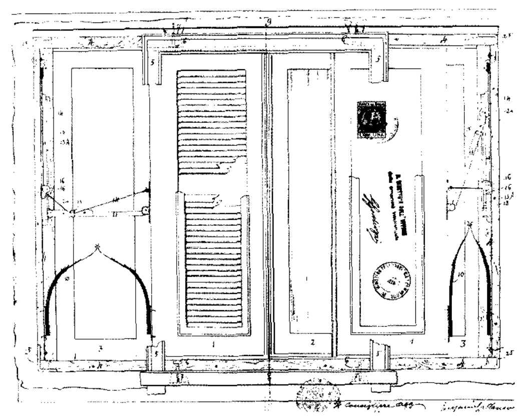

Figure 1
E. Cattaneo's enbloc patented window

Only few years later, G. Pagano and G. Levi Montalcini designed Palazzo Gualino (1928–29), which is believed to be the first Italian Razionalismo work. Here the new technology of horizontal slit windows —promptly called «in bed» as opposed to conventional vertical range ones— is an evidence of openness to experimentation, though within the boundaries of a classically paged up façade (fig. 2).

A horizontal window can fully span across bearers and allow for ample brightness and ventilation of premises. But only if combined with an up and down latching system this kind of window becomes suitable for modern interior layouts and decoration. Up and down control systems —which were to attract large numbers of patent applications— are the most fit for horizontal windows —no shutter gets in the way, windows can be placed at building corners, walls are fully usable up to the very window. They also fill health requirements for they allow for gradual air change. Moreover, they innovate shading systems because they suppress conventional blinds and shutters and introduce roller shaders.

The story of the large wooden frame —over 13 ft. long— which was manufactured for the front of Casa del Fascio, in Como (G. Terragni, 1932–36), is eloquent in this connection. The early proposal wanted it to be made out of drawn iron but it was rejected because it didn't suit the idea of a whole span clear of posts, nor the need for an up-and-down latching system. This, in turn, was a must in the light

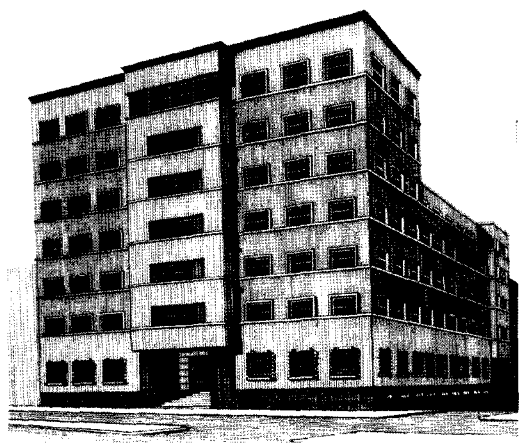

Figure 2
Palazzo Gualino in Turin (G. Pagano, G. Levi Montalcini, 1928–29)

of the frame unusual size, but still little tested as an iron structure (Poretti, 1998). A wooden frame with no middle posts was eventually chosen. It included three overlapping wings to be controlled through three hempen belts and a sash weight mechanism patented in those years by Colombo & Clerici Co. —the same Firm which was to manufacture the whole rig (fig. 3).[4] In this story, the reasons of function are associated with a will for continuing a building tradition that often accounts for the use of most common materials, not only in high profile projects but also in such housing programs in which simple common taste is reflected —all this helping outline the character of Italian architecture between the two wars.

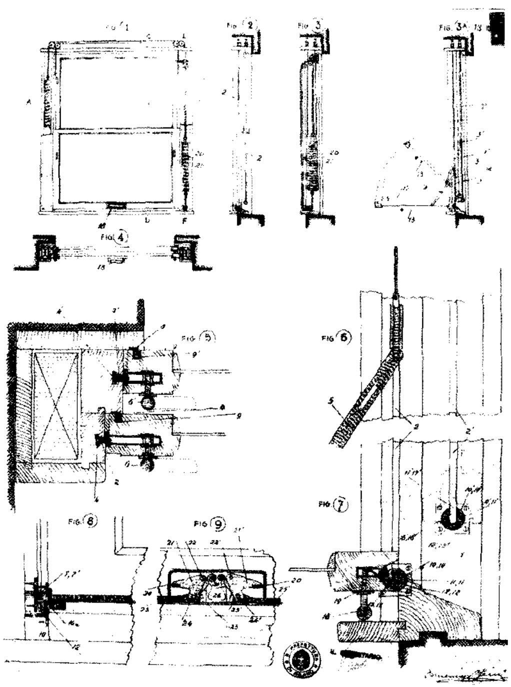

Figure 3
Colombo & Clerici's patented frame, 1933

Terragni's building severe and monumental façade will therefore be finished off by wooden windows, while more modern materials such as steel will be left to courtyard prospects (fig. 4).

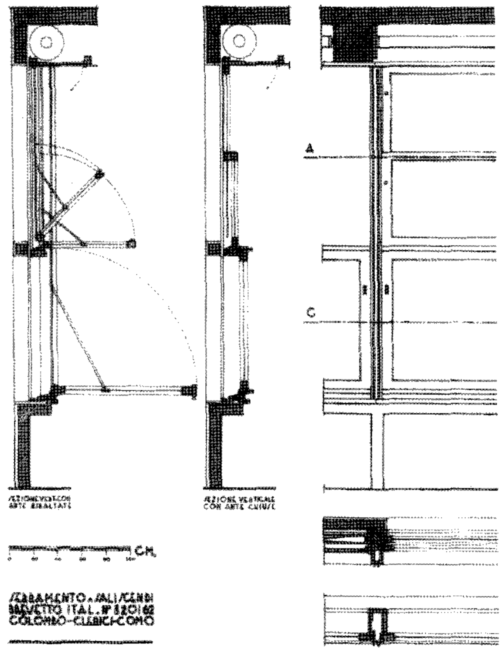

Figure 4
Como Casa del Fascio window frame (G. Terragni, 1932–36)

In the autarky years, wood —like any other material— had to undergo a close evaluation concerning its economic dependance upon foreign supply. Most of lumber used for fixed or sliding frames and for shutters and blinds used to come from abroad. Potential alternate material could be a mix of resins and bonding agents with sawdust, chips, shavings, wood flour. Some agricultural by-products such as hemp processing waste were also considered for use[5]. Together with these low-feasibilty proposals, more realistic ideas are found in the records of the patents office. And they are such as could not only make window frames and related controls safer and lighter, but also help the country's economy since the iron content of mechanisms is reduced. Such is the case of a wooden window frame[6] which was advertised in the magazine «Casabella» as a «home product» —its cumbersome and expensive counterweights are replaced by springs which reduce «to less than one/tenth» the content of ferrous materials in it (Matricardi,1940). The shutter weight is offset by the springs combined with pulleys and rollers connected to the moving shutter, to compensate the springs variable attitude and keep the shutter on balance (fig. 5).

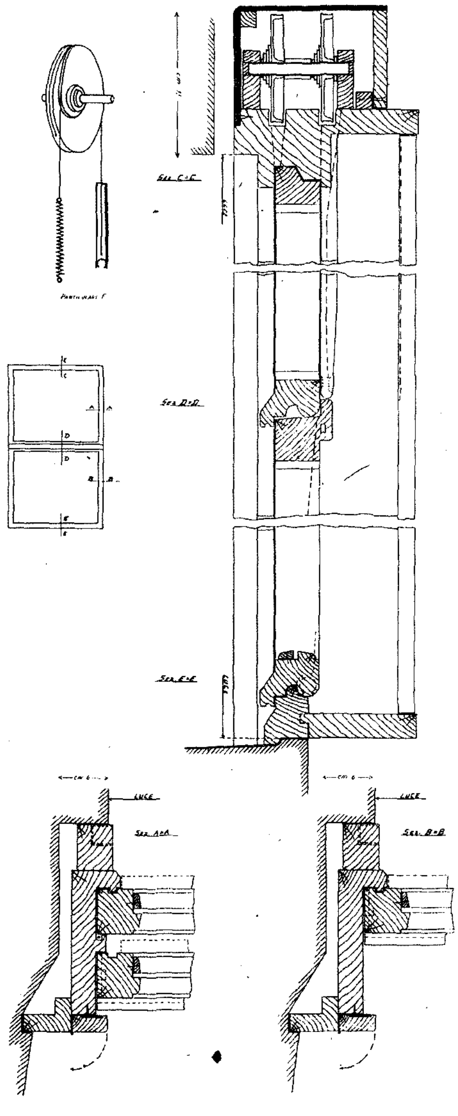

Figure 5
The autarchic wooden frame advertised in «Casabella»

Evolution of metallic bars

Metallic window frames have been used in Italy since 19th century. Though they don't have a multicentury history, like wooden ones, they can be considered quite ordinary stuff. Their use is closely related to the development of the iron industry which has made mass production of hot drawn bars possible since mid —Eighteen Hundreds. Available sections then were Z, L, T. They were called «normal sections» and used to be welded or riveted together to form the joints and ledges to fit in glass panes which used to be puttied in.

Higher structural capability than wood, incombustibility, non-deformability made metallic sections a market success. Still their origin from a strictly industrial process stamped them as a merely functional object and for long time restricted their use to factories and to service areas of residential buildings. Later on, in the Nineteen-twenties, the very same «restricting» connotation is revalued upwards to become a «modernity» mark. According to this reassessment, window frames become sophisticated devices which ought to be manufactured «with the same technical standards used to create air/ water sealing systems of railway cars, large aircraft, ships, motor cars», that is to say the same technologies and processes of the most advanced industrial products (Minnucci, 1931). The evolution of metallic window frames will indeed focus upon the development of section bars. As a matter of fact, air and water tightness, eccessive weight, deformabilitystill remained normal bars weak points, driving research to articulate sections geometry, anticipating the development of more modern «ferrofinestra» and to assess the potential of tubular sections.

Since the Tens, patents have been granted which would improve the glass-frame joint. More complex sections were studied, air space was created between ledges using elastic seals, structural steel was coupled with rubber to ensure airtightness (fig 6).[7]

Tubular sections begin to show in the patents file of those years. Their purpose is to combine air/water tightness with the maximum possible lightness.[8] These early innovations help define the steps needed to upgrade the component performance. But only the launch, in the Twenties, of a special section bar called «ferrofinestra» or «rationale section» would allow a marked improvement in window frames performance.

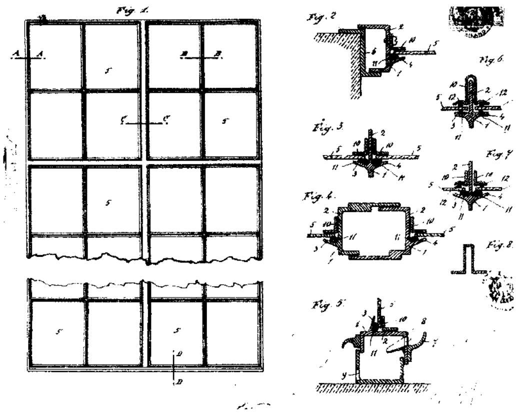

Figure 6
Metallic frame patented by C. Aiolfi, 1916

The new section will become a modernity symbol thanks to the innovation of its manufacturing process based on mass production of few section series suitable to fit all types of window frames —with the ensuing factory organization.

Ferrofinestra was already widely used in more metal-rich, metallurgically advanced European countries. It is introduced on the Italian market with the backing of foreign producers who guarantee initial supplies until Italy's industry becomes capable to hot-mill perfectly linear, complex section, accurately processed iron bars. Materials involved are Martin-Siemens steel and rust-proof copper steel.

Compared with conventional section bars, ferrofinestra is cheaper, lighter, more indeformable. It also allows better tightness and durability. Moreover, it improves premises brightness since no heavy fittings are required as with old bars —one bar fits all building requirements.

Italian industry furtherly refines ferrofinestra design. ILVA, for one, rounds off sharp edges. This improves protective coating adhesion. They also move on to wedge-shaped wings, which improve surface contact compared to parallel wings.

However modern, and differently from what happens in Northern Europe, ferrofinestra is not to become a bestseller with Italy's standard building industry. Basically, it will be used for its structural qualities —that is large window walls of institutional buildings. Still, whenever its qualities do not justify its use, ferrofinestra will be used in secondary prospects.

As a matter of fact, it is emblematic the use of ferrofinestra in such important buildings of the Thirties as Scuola di Matematica in Rome Città Universitaria (G. Ponti, 1935–35). Here ferrofinestra, associated with a further modern material called Termolux,[9] is used on the fronts of a most modern part of the building which, however, sits in the back of the whole project, thus leaving the stately, higher profile main façade to wooden window frames (Mornati, 2002) (fig. 7). In G. Terragni's masterpiece, Como Casa del Fascio, too, ferrofinestra is confined —as we said— to courtyard prospects.

Beyond bar sections, research paths stretch into metallic windows opening ways. A large number of patents cover this issue. Weight is always a main factor, for it is a test-conditioning element. As regards normal size windows, conventional swinging or transom openings are confirmed; up-and-down

Figure 7
Metallic frames of Scuola di Matematica's secondary section at Rome Città Universitaria (G. Ponti, 1932–35)

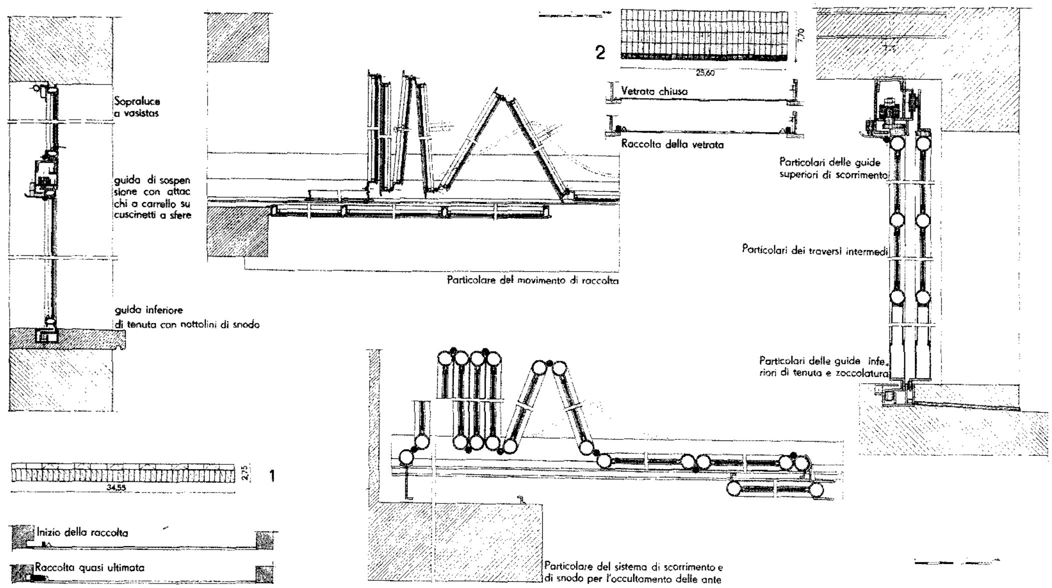

Figure 8
Curti Co.'s 1931 patent as shown in «Casabella»

latching systems are unusual. The biggest innovation will occur in larger glazed frames, where «book opening systems' are tested. In this connection, Curti Co., one of Italy's best known iron frame producers, gets (1931) patent rights covering an iron window system with foldable frames[10] (fig. 8). This will be fitted few years later at Bologna Istituto Superiore di Ingegneria (G. Vaccaro,1935) and will include ferrofinestra sections (fig. 9). The same will be fitted in the indoor swimming pool area of Forlì Casa del Balilla (C. Valle 1936), where Mannesmann tubes will be used (L. S. 1936) (fig. 10).

Studies on hollow sections pursued in the beginning a number of aims. Among them, less weight, less deformability, no elasticity loss, possibility of inserting insulating materials in cavities to improve the frame thermal resistance. Efforts were also made to reproduce wood familiar profiles in section bars.[11] These studies were furtherly promoted, as was research on light alloys,[12] when Italy entered the autarky period. Following this, what had been an advice to reduce imports of building materials, becomes a prohibition.

Ferrofinestra, too, is then subject to close economic scrutiny and the result is that its use reduces iron needs by 50 percent against normal iron section bars (Bartoli,1938). Ferrofinestra is since declared the most autarchic frame material (fig. 11).

Import restrictions, however, must have quite light an impact if, at the peak of the autarky stage, ferrofinestra is used in large quantities for the 168 imposing glass windows of Palazzo della Civiltà Italiana (G. Guerrini, A. Lapadula, M. Romano, 1939–43), not confined —this time— to minor prospects. Although in this building history, attempts are made —with no results— to dignify iron with some more valuable coating, those large big windows still stand out with their stern look in line with the building image. In this work, however, no studs slightness is pursued and a 50 mm. Ferrofinestra section is used, that is the largest available profile in ILVA sections stock. Such bar is assembled in a threesome arrangement resulting in a total 10 cms. section, thus bestowing on window frames the same monumental character of the whole building (fig. 12).

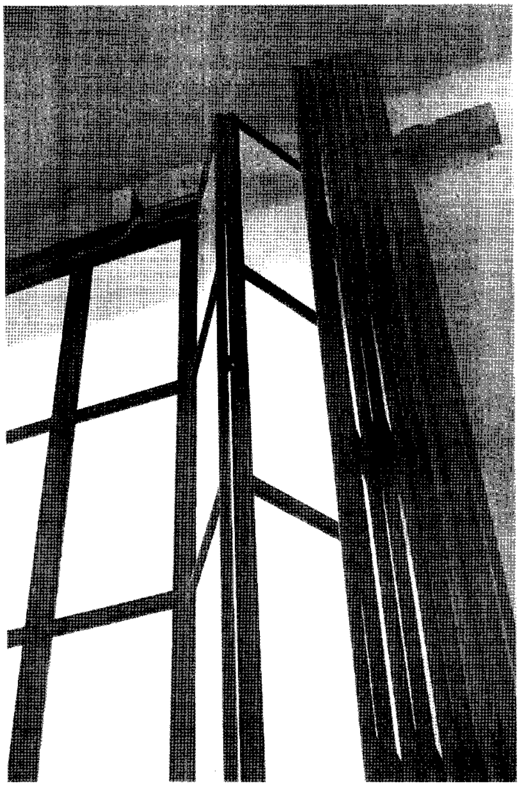

Figure 9
Detail of foldable sliding wings of the Scuola Superiore di Ingegneria glazed windows in Bologna (G. Vaccaro, 1936)

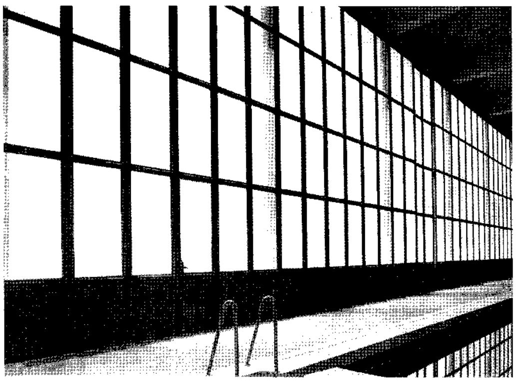

Figure 10
Foldable sliding wings of Casa del Balilla glazed window, in Forlì (C. Valle, 1936)

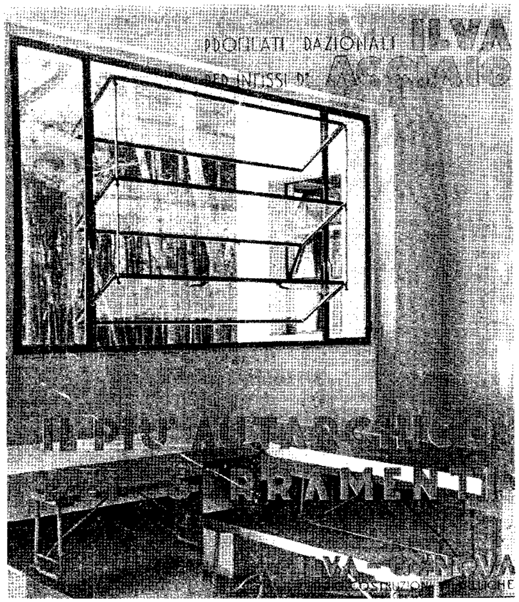

Figure 11
An ILVA advertisement appeared in «Casabella», nos. 138–139–140, in 1939

«Liquid mire»

Thus Ugo Ojetti would synthesize his disdain for the popularity enjoyed by reinforced concrete in Italy —as well as elsewhere— despite the harsh debate that came with it (Pagano, 1935). Though this material was routinely used in the Twenties for load bearing structures and various construction elements, its use for the production of window frames was not as widely accepted. The scantiness of research in this sector is reflected in the small number of patent applications filed with the office and, most of all, in the little use of reinforced concrete frames (Mornati, 2001).

Ordinary glass panes coupled with concrete bars had been used, since the Twenties, to produce transparent coverings imitating better known metallic or wooden carpentry. Likewise, the first patented swinging wing frames —their French origin is proof of their wider use over there— are only transferring standard concrete technology into conventional patterns as far as look, bearing sections and opening

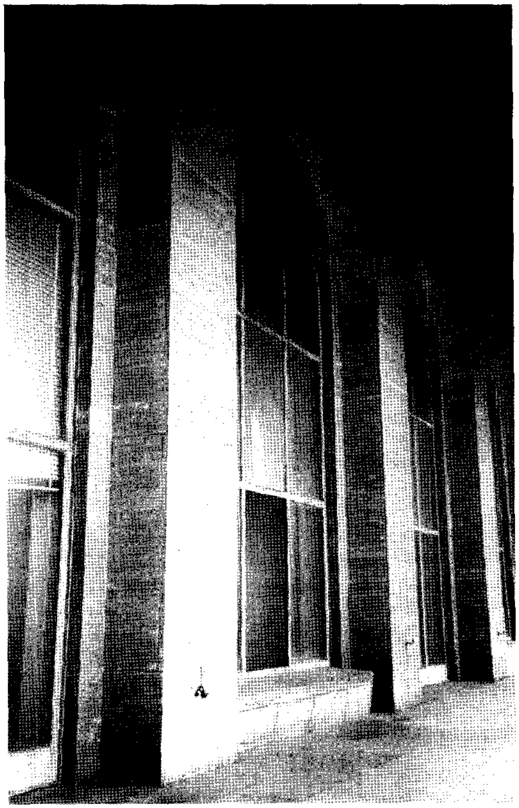

Figure 12
Sequence of large window frames of Palazzo della Civiltà Italiana in Rome (G. Guerrini, A. Lapadula,M. Romano, 1939–43)

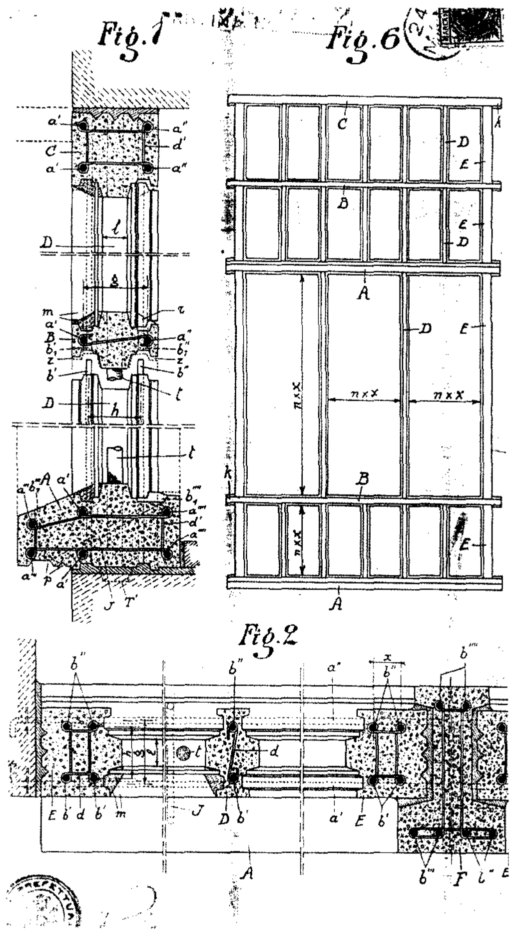

Figure 13
A picture of the French patent for reinforced concrete window frames, 1927

systems are concerned. No consideration is given to material different mechanical capabilities.[13]

Some interest arouses about concrete frame transparent walls as an alternative to concrete and glass tiles which permit traslucid walls, as shown in one of the most up-to-date handbooks of the Thirties (Griffini, 1932). The early instances consisted of large-size prefabricated monolithic frames which were assembled with the help of a falsework. Problems of weight, on site storage, handling and breaking risks of such cumbersome elements eventually suggested to break them up into shorter linear pieces which would be held together by protruding stress rods or pins[14] (fig. 13). This approach allowed to realize glazed frames of all sizes, very much like concrete and glass tile technology.[15]

Still, G. Minnucci, with direct reference to glazed walls, while illustrating the good qualities of reinforced concrete frames (Minnucci 1929), stressing their fine economics, low maintenance requirements, incombustibility, weather-proof ability, declared them more suitable for industrial buildings.[16]

Among the very few uses of this technology, one peculiar instance are the two series of five large «pumice concrete' glazed windows made for Rome

Palazzo della Civiltà Romana (P. Aschieri, C. Pascoletti, D. Bernardini, E. Peressutti, 1939–43) (fig. 14). Here, too, an evidence of modernity is confined to side prospects, leaving to the mighty blind walls of main façade to stand for the Museum institution.

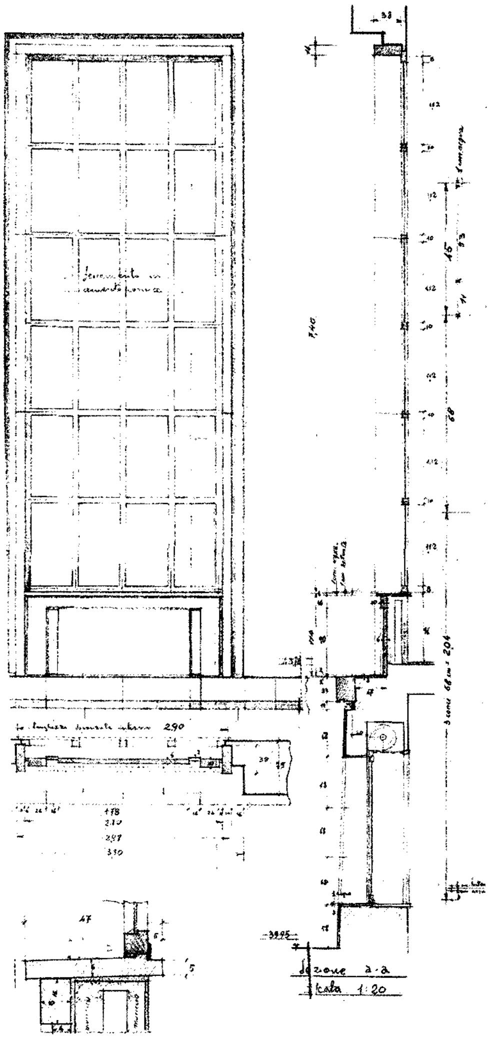

Figure 14
Pumice concrete window frame, Palazzo della Civiltà Romana, Rome (P. Aschieri, C. Pascoletti, D. Bernardini, E. Peressutti, 1939–43)

Pumice concrete is a mix of Lipari pumice grit and Portland cement, reinforced with 3–4 mms thin rods tied with iron thread. The mixture is cast into dismountable scagliola boxes so as to get a very fine surface dressing. Window frames produced with this technology are as light as ferrofinestra ones (15 kg/sq.mt.), and feature good strength and mechanical resistance (Albert, 1939). The windows of the Palazzo building are 7.40 ¥ 2.98 mt sized, they are divided into 4 horizontal and 6 vertical spans and carry vertical and across hexagonal bars. One of the horizontal spans is made of transom windows which can be opened thanks to metallic sub-frames. Reinforced concrete swinging wings are indeed a problem, not only because of their weight but also for the awkward connection between hinges and frames and the material brittleness in the areas of hinges and edges connection.

The only truly innovating proposal comes in 1939 from G. D'Aronco, a scholar from Friuli who researched various reinforced concrete applications. Different from other researchers, who would fit (new) materials to conventional, long tested control systems, he filed a patent application for a window frame where a combination of flexure, cut and torsional stress is the solution. Together with a cross bar section —«which best suits an iron-concrete combination»— and a quite fluid, finely batched mixture which allows thinner sections, D'Aronco deviced a complex control system which does away with side hinges and has the wing rest entirely on a mobile bearing, lower down,which is hinged on to the wall below the window.[17] This way the wing and the frame are stressed only to the extent needed to ensure frame airtightness (fig. 15).

As far as reinforced concrete is concerned, research on building materials with a potential to satisfy the autarky environment, focussed on cutting down iron use. Odd proposals were put forward such as resorting to bamboo canes to take up tensile stress.

On the same line, research on tubular metallic sections comes now handy to manufacture a new profile called «metalcemento». This is made up of stainless tubular elements (other materials are also usable such as asbestos, cem, synthetic resins, plastics) which can be coupled to each other to reach required sizes. Cement is cast in between over a metallic bracing to make a stiff, monolithic block. Iron requirement is slashed down by a 1 to 20 ratio

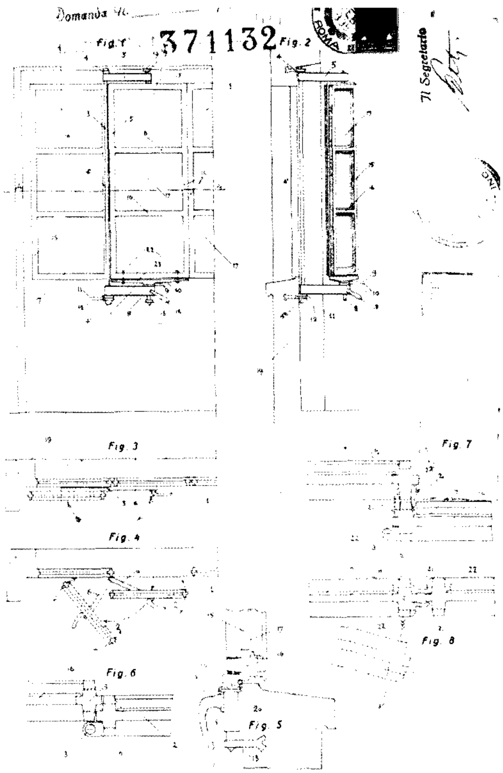

Figure 15
G. D'Aronco's patented reinforced concrete window frame, 1939

compared to metal frames (Diotallevi and Marescotti, 1940).

As regards current building practice in Italy, concrete window frames will be used almost exclusively in residential projects. This bears witness to their utilitarian vocation. The use of concrete window frames in other types of buildings must be considered as some sort of promotion of involved materials modernity, devoid of any architectural value whatsoever. This confirming, at several years distance, Minnucci's perplexities.

Notes

1. Materials of Archivio Brevetti (Patent Office files), from which the patents we described were drawn, is kept at the National Central Archives's, Patents Fund. We would like to remark that such materials are a very special source for researchers because —although many proposals have been used by the building industry, many others remained in a theory stage, without a market outlet. And this describes the invention's limits.
2. Still in 1937, Pagano comments on reinforced concrete potential of use: «Descending from such technology of skeleton structure are the rhythm of long-footage horizontal windows, the pillaring layout as well as the rhythm of wide-spanning, superposed balconies». (Pagano, 1937).
3. «A complete mechanical window featuring automatic locks and a safety device», by E. Cattaneo, Patent No 203761, 1922.
4. Colombo & Clerici Co. filed in 1932 patent No. 307018 «Improvements to bi-laterally controlled sliding windows». In 1933, patent No. 320162, under the same heading. For more details. (Mornati, 199b).
5. «Elementary window frame profiles and decorations formed through wooden concrete pressing», by E. Adami, patent No. 374412, 1939.
6. «Improved window frame with two or more vertically sliding wings», G. Rossi, patent No. 370852, 1939.
7. «Improved no-putty locking systems for window glass and frames, in general», C. Aiolfi, patent No. 154361, 1916; «Mode de construction de fenetres, portes et chassis metalliquest», A. P. Dousse», patent No. 219305, 1923.
8. «New window framing system», by P. Marchesi, patent No. 194782, 1921.
9. Termolux is a diffusion glass with thermal and acoustic insulation properties made out of two layers of stretched glass plied to an inside glass thread layer (Repertorio, 1934).
10. «Vertical foldable frame shutting or door system», Curti S.A., patent No. 303973, 1931.
11. «Metallic window or door frame», C. Grassi, patent No. 311736, 1932. The invention description stresses the possibility of coming up with the «same look as any other wooden frame».
12. The success of light alloys had been helped by the the large use of anticorodal special sections, particularly in connection with the frames of Milan Palazzo Montecatini (1936), due to Ponti, Fornaroli, Soncini. Anticorodal is a silver hue aluminum alloy mechanically comparable with extra mild steel. It is highly stress resistant as well as weather and chemicals proof (Repertorio, 1934).
13. «Chassis en ciment armeé pour fenetres a guillotine», J. Clément, patent No. 194593, 1921.
14. «Glazed windows brushing, molding process and tooling», Le Chassis en ciment armeé M. T., patent No. 258452, 1927.

15. As a matter of fact this patent was taken over by S.A.I.V.A. in 1939. Società Acc. It. Vetrocemento armato is a well-known corporation which has operated in the glass tiles sector since 1899.
16. Minnucci believes that concrete window frames are overly heavy but still a good value. Therefore they could used in low-cost housing projects, where economic factors are most important.
17. «Double-hinged fitting system for concrete glazed windows frames, allowing for perfect weather-proofing», G. D'Aronco, patent No. 371132, 1939. D'Aronco will also get patent rights for collapsible formworks to produce window frames. Still on the occasion of his own house expansion, Mr. D'Aronco resorts to concrete frames not based on his patented system, choosing to link wings and frame by means of conventional hinges. This is indirect proof of the theoretical nature of his research and rather uses (Mornati 2001; Bertagnin, Chinellato e Tubaro, 1999).

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