Readings/Rereadings

The Representation of Constructive Forms

Federico Fallavollita

Introduction

The volume *La représentation des structures constructives* by Adrian Gheorghiu and Virgil Dragomir [Gheorghiu, Dragomir 1968], the former an architect and the latter an engineer, was published in France in 1968 as a translation of a previous Romanian edition (fig. 1) [1]. It is a book that I regard as a working companion and, in a certain sense, a pivotal reference in my own education: for nearly twenty years it has accompanied my research, ever since I first studied it during my doctoral work at Sapienza University of Rome, where it served as an indispensable text for understanding the geometric nature of ruled surfaces. Over the years, I have come to appreciate that this work is not merely a technical manual; it is, rather, a true treatise on the profound relationship between form, structure, and representation, capable of speaking even today to architects, engineers, and scholars concerned with the logic of spatial configuration.

The book is organized into three principal sections. The first, *Perspective Drawing, Structural Statics and the Aesthetics* [2], is a lengthy conceptual and technical introduction devoted to the role of drawing, particularly axonometric representation, as an instrument of thought and as a method for analyzing architectural forms. The second, *From Geometric Surfaces to Thin Curved Shells*, offers an extensive treatment of curved surfaces, interpreted not merely as geometric objects but as genuine constructive devices. Each type of surface is presented in relation to historical and contemporary examples, producing a sort of visual atlas of curved structures. The third part, *From Polyhedra to Space Frames*, focuses on polyhedral geometries and spatial reticular structures, demonstrating how a deep understanding of polyhedra remains indispensable today for complex three-dimensional systems ranging from geodesic domes to large lightweight coverings. Notably, this section includes a chapter entitled *Framed Structures*, which anticipates developments in mesh geometry and, to a certain extent, in the geometry of folded surfaces associated with origami mathematics [Pottmann et al. 2007], a field that has experienced significant growth in recent years, partly owing to the digital revolution.

From the opening pages, the authors clarify the aim of the work: to present in a systematic way the geometric principles underlying the most recent architectural structures

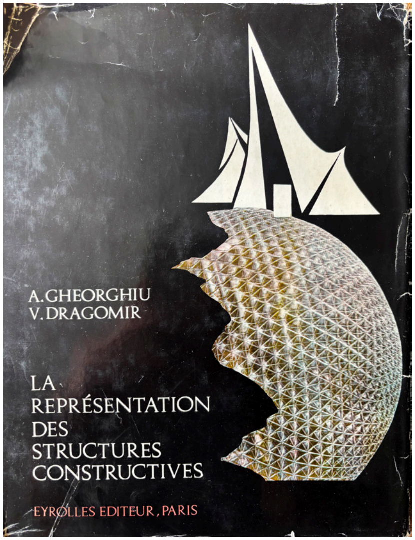


Fig. 1. Cover of the first French edition of the book [Gheorghiu, Dragomir 1968].

https://doi.org/10.26375/disegno.17.2025.26 diségno ISSN 2533-2899
BY-NC-ND

of the 1960s, and to demonstrate how axonometric drawing constitutes the most suitable language for understanding, managing, and representing them. This aim is not secondary; it reflects a specific epistemological stance whereby geometry is not a language superimposed upon architecture, but a cognitive system that precedes and informs the design process itself.

The gap between technical manuals and the design process

One of the authors' most prescient observations concerns the fragmentation of technical manuals. Most specialist texts, Gheorghiu and Dragomir note, present only the outcome of a project: photographs, simplified elevations, partial construction diagrams. What is missing is the continuity of the logical process: data selection, geometric decisions, and the genesis of form. In other words, what is absent is the 'thinking' that mediates between problem and solution. For this reason, the book does not aim to present only geometric results; it seeks instead to reconstruct the methodological path that links perception, representation, verification, and construction.

A second shortcoming, more conceptual in nature, further complicates this situation: the geometry of representations has not kept pace with developments in structural statics. While computational methods have become increasingly sophisticated, the geometric component often remains tied to traditional forms, unable to accompany technical imagination toward new spatial solutions. The result is a growing disconnect between what can be calculated and what can be imagined and represented. Geometry, by contrast, ought to serve as a bridge: a shared language enabling architects and engineers to communicate visions and methods.

The role of parallel perspective or axonometry

The first part of the book offers an in-depth review of techniques of parallel perspective drawing, understood not as a mere representational method but as a genuine tool for discovering form. For Gheorghiu and Dragomir, parallel perspective, unlike orthographic double projections, enables a closer relationship between image and space: it preserves parallelisms, proportional relationships, and linearity while providing an immediate and, crucially, manipulable reading of volume.

For this reason, axonometry becomes the central language of the volume. The Pohlke-Schwarz theorem, which guarantees the possibility of representing any three-dimensional system through a single two-dimensional image, serves as the theoretical basis for constructing a geometry of structures that is both rigorous and intuitive. In axonometry, one may directly take measurements from the drawing, assemble and decompose forms, and assess the coherence of a structure. In this sense, axonometric drawing functions not merely as a representational device but as a 'thinking machine'.

Structure, form, and image

The theme of interdependence between form and structure is approached through a critical re-examination of the tradition of stereotomy. While in the past the form of masonry vaults resulted from a complex balance between geometry and technique, the advent of new materials, steel, reinforced concrete, membranes, prefabricated components, has radically altered those logics. Yet, the authors argue, the fundamental principle remains unchanged: structure must be conceived as a coherent system of lines, surfaces, and volumes, and the spatial image that emerges must express a synthesis of function, technique, and form.

Image is not ornament, nor a mere visual effect: it is the manifestation of constructive order. A building 'expresses' itself through its image, which conveys the internal logic of the structure to the observer. It is therefore essential that geometry be fully aware of structural requirements: a form lacking constructive logic produces a misleading image, whereas a form generated by a coherent structural system yields an image that is clear, historically grounded, and culturally meaningful.

The authors emphasize the role of intuition in the genesis of any project. They cite a well-known reflection by Pier Luigi Nervi, who observed that ancient builders were able to conceive extraordinary works without modern computational tools because they possessed a profound intuition of form and forces. For Nervi, as for the authors of the book, calculation cannot replace intuition, which instead emerges from geometric understanding and constructive experience.

The preliminary image of the structure, the one that arises prior to calculation, is, for Gheorghiu and Dragomir, the heart of the design process. This image must be both evocative and rigorous, capable of evolving through two series of approximations: one linked to statics, the other to representation. Neither can progress independently: form cannot be defined without considering forces, and statics cannot be understood without a form that represents it correctly.

'Descriptive Geometry' and axonometry compared

The book devotes a considerable attention to the relationship between image, projection, and drawing. The three-dimensional image constitutes a complex synthesis of visual, tactile, and motor perceptions; technical drawing, however, must reduce this complexity to a construction governed by geometric principles. Conical and cylindrical projections define fundamental relationships between planes, congruence, homothety, affinity, and projectivity. These are not mere theoretical abstractions but operational tools through which space can be transformed, analyzed, and represented.

The authors do not deny the importance of double orthogonal projections for the study of form; however, they note that perceptual intuition relies on a more immediate spatial image, rendered effectively by axonometry. Both methods share a crucial feature: they produce reciprocal representations, allowing one to reconstruct space from the image and, conversely, to intervene in the image as though operating directly in three-dimensional space.

The comparison between Descriptive Geometry (understood by the authors as double orthogonal projection) and axonometry is developed with clarity. Monge's double projection requires complex notation and does not allow an immediate reading of volume. Axonometry, by contrast, provides a single synthetic image that preserves parallelisms and proportions and allows the use of three independent scales along the axes. For this reason, the authors regard parallel perspective as an instrument more closely aligned with design logic and more useful for describing complex structures such as latticed or surface-based systems (fig. 2).

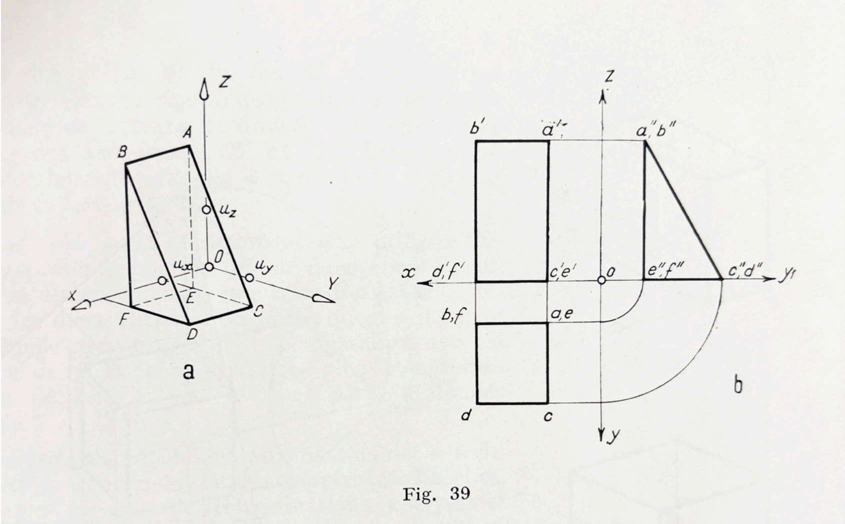


Fig. 2. Comparison between the drawing in 'Descriptive Geometry' and oblique axonometry [Gheorghiu, Dragomir 1968, fig. 39, p. 41].

A particularly interesting observation concerns the choice of axes and unit scales: the authors demonstrate how an ill-considered choice can distort the image to the point of rendering it unusable, whereas a well-considered choice, often guided by the construction of a 'reference cube', produces a balanced, legible image. This attention to graphic detail confirms that the geometry of representations is not merely a technical discipline but a genuine art of perception.

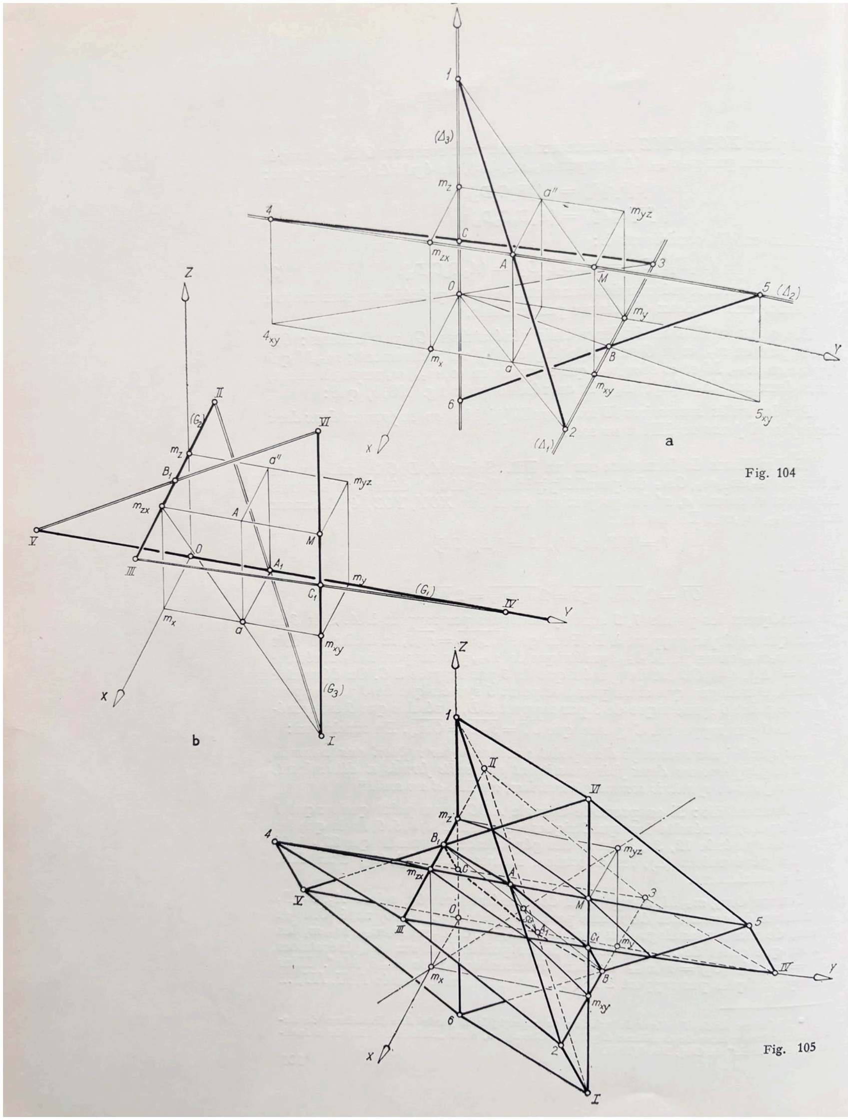
Another remark on axonometry, especially noteworthy, deserves to be quoted: "The spatial image does not correspond to human vision (at finite distance), as in conical perspective, but it is sufficiently good, especially for small objects, or for very large objects viewed from a great distance (as a whole)" (p. 42). The implicit comparison with perspective and visual perception opens a wide field of reflection; it is enough to note, however, that the authors are fully aware of two fundamental modes of representing the world: as it looks and as it is [Arnheim 2009]. Axonometry emerges, in their interpretation, as an intermediate solution, capable of describing the objective structure of forms without straying too far from their perceptual appearance.

A personal example: the constructive parallelepiped

Among the many insights and indications contained in the book, one has been particularly decisive for me: the construction of what I call the 'constructive parallelepiped' [3], described in the section *Problèmes de fermeture sur un HR* (fig. 3). During my doctoral research, I was studying the exact generation of a ruled hyperboloid defined by three skew lines [Fallavollita 2008] [4]. Techniques based on interpolating generatrixes proved insufficient for constructing the surface in a complete and accurate way: they produced approximated surfaces, not rigorously quadratic ones [5]. I had come to understand, partly thanks to reading David Hilbert and Stefan Cohn-Vossen's *Intuitive Geometry* [Hilbert, Cohn-Vossen 1960], that an elliptic hyperboloid may be obtained by deforming a hyperboloid of revolution through an affine transformation. But to apply this idea, it was essential to determine precisely the centre of a general hyperboloid.

The construction provided by Gheorghiu and Dragomir offers exactly this: a rigorous geometric method based on constructing a parallelepiped associated with the directrices, which makes it possible to locate the centre of the surface and thus to generate the hyperboloid exactly. Though conceptually simple, it is highly effective and decisively shaped my understanding of the geometric genesis of the elliptic hyperboloid as a quadratic ruled surface resting upon three given skew lines (fig. 4). The procedure itself is extremely simple: it consists in determining the parallel

Fig. 3. The construction of the 'constructing parallelepiped' [Gheorghiu, Dragomir 1968, fig.105, p. 102].



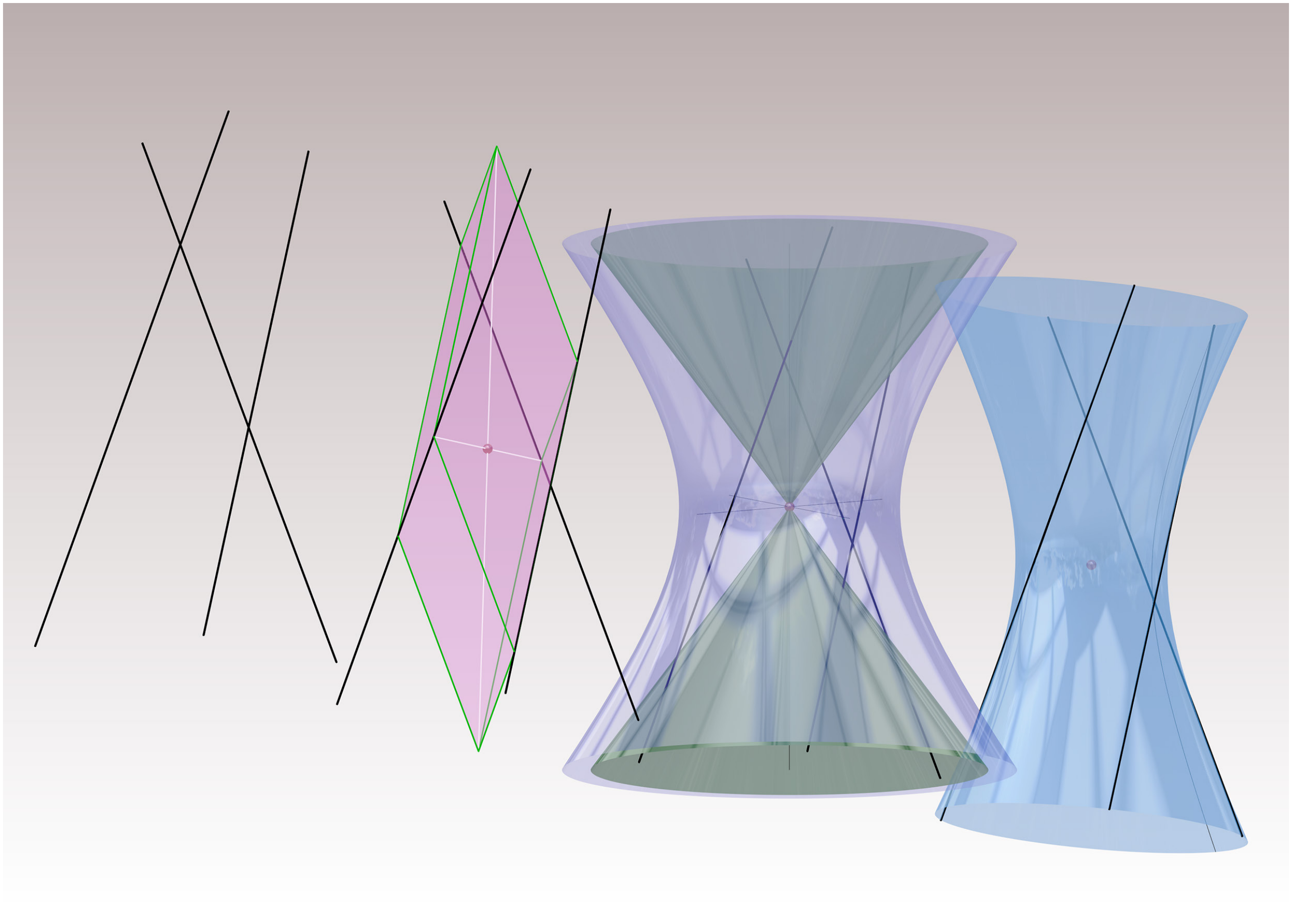


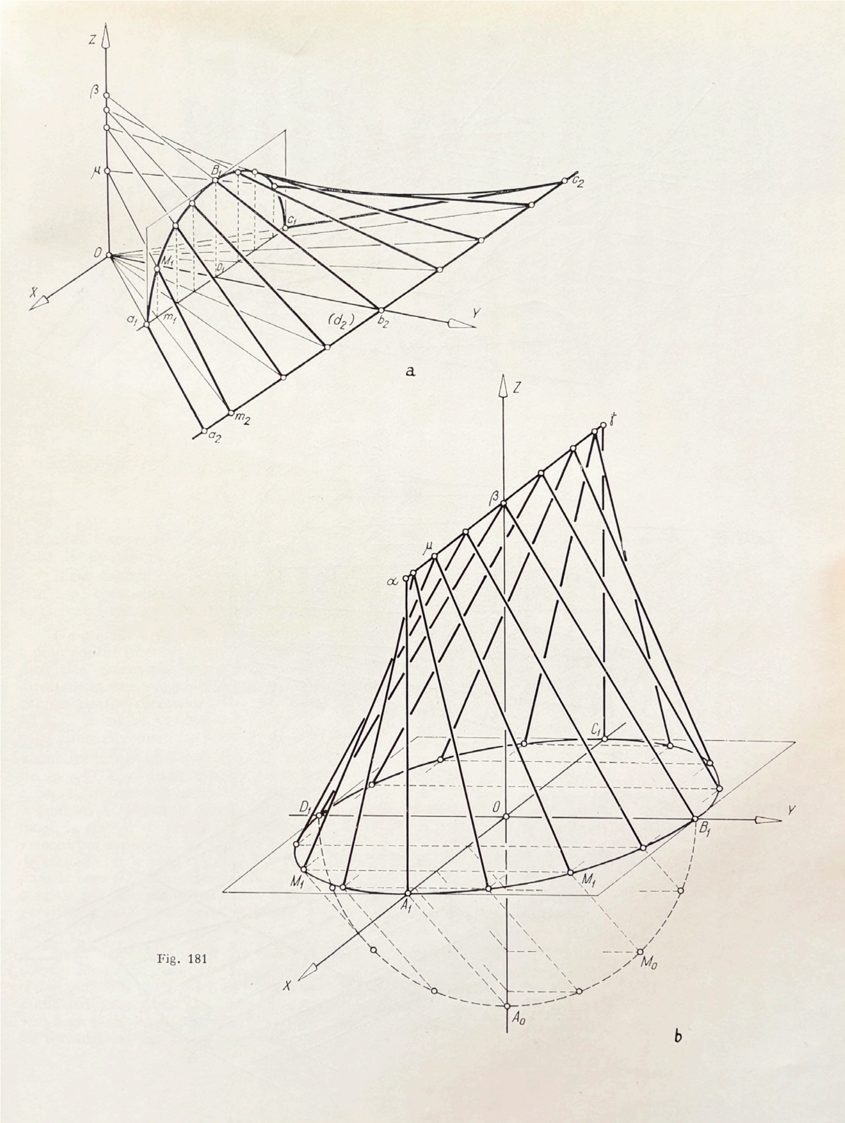
Fig. 4. The construction of the elliptic hyperboloid from three skew lines (graphic elaboration by the author).

planes passing through each of the three skew lines. These planes are obtained by constructing them in pairs. First, one superimposes the first line on the second and determines the plane passing through both; then one transfers this plane onto the first line to obtain the parallel plane through it. Repeating this operation for each pair of lines yields six planes in total: three pairs of parallel planes defining the constructive parallelepiped.

Conclusions

In the concluding section, the authors present the geometry of structures as a central discipline, capable of guiding design imagination far beyond what calculation alone may verify. Geometry is not an auxiliary language nor a mere technical instrument: it is the foundation through which form may be understood and controlled, its structural behaviour anticipated, and its aesthetic meaning assessed.

Fig. 5. The conoids [Gheorghiu, Dragomir 1968, fig.181, p. 167].



The new possibilities offered by computational methods greatly broaden the spectrum of realizable forms; yet such forms, to be persuasive and correct, must be rooted in a solid geometric understanding. In this respect, the authors argue, the Geometry of structures must develop the algorithms that will enable computers to assist, rather than replace, creative imagination.

The book thus situates itself within a broader theme: the Geometry of forms, structures, and representations in contemporary architecture and engineering.

More than fifty years after its publication, it remains remarkably relevant: it offers a method, a language, and a vision capable of addressing the complexity of contemporary forms without abandoning the theoretical robustness characteristic of the great European geometric tradition.

My final remark concerns the value of the geometric constructions and the related drawings (figs. 5-7). The work was conceived and written shortly before the digital revolution that transformed graphic representation. Yet the quality of the images does not suffer in the least: geometric forms are rendered with great clarity, enabling an impeccable reading of three-dimensional configurations.

This result is achieved with extremely simple graphic means: only two-line weights, a thin one for constructions and a thicker one for the final result, that is, for the forms depicted. The viewpoints chosen are always optimal and functional to the procedures described. No graphic embellishment, and yet the effectiveness is remarkable.

Fig. 6. Dodecahedral grids [Gheorghiu, Dragomir 1968, fig. 310, p. 266].

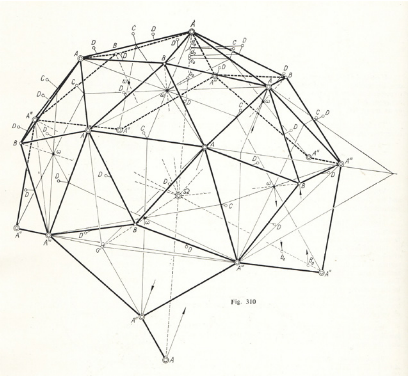
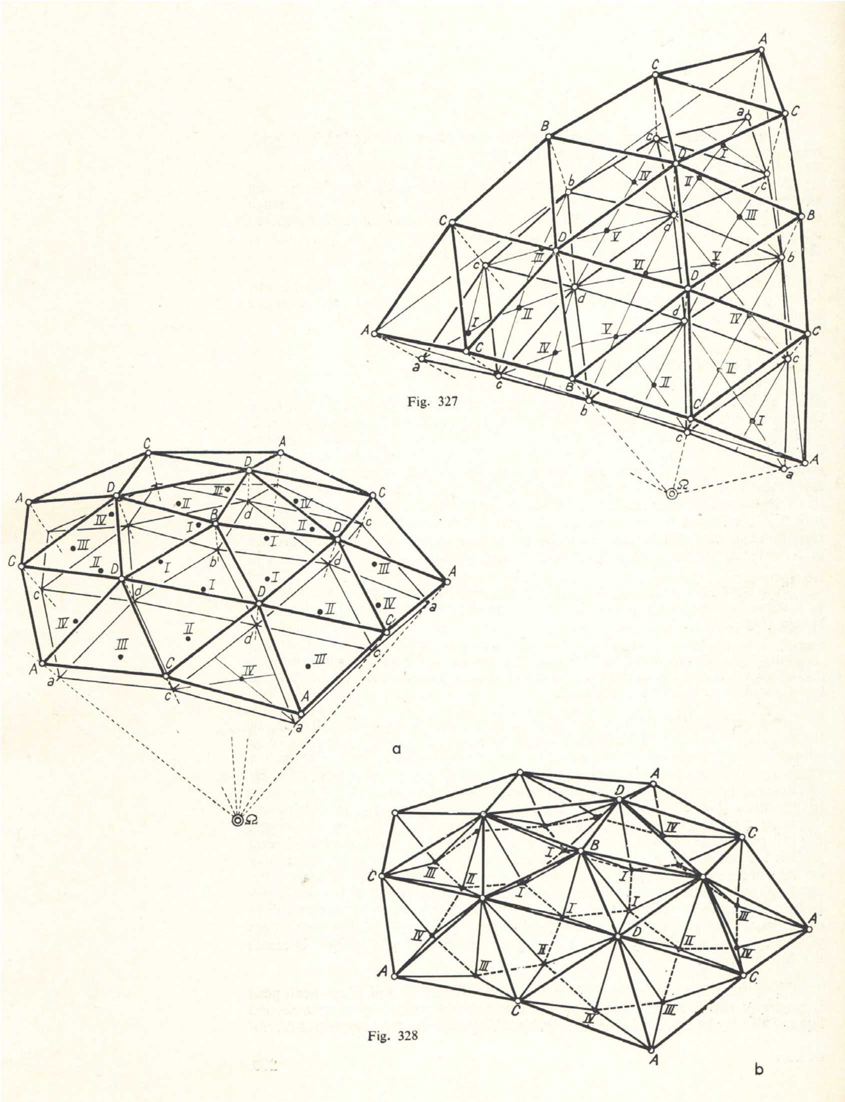


Fig. 7. Double-layer framed grids [Gheorghiu, Dragomir 1978, figs. 327 and 328, p. 287].



As for the constructions themselves, at first glance one might assume that they are now 'obsolete' or 'superfluous', since today it is possible to operate directly in three-dimensional space. This judgement, however, would be unfounded. Most of the procedures proposed in the text correspond to operations that, even in contemporary digital environments, are applied directly to spatial forms. Axonometry is employed as a tool for investigating geometric configurations in an immediate and spatial manner. Very few constructions are rendered unnecessary by digital modeling.

The constructions presented thus remain fully relevant and constitute an effective aid for understanding, generating, and analyzing surfaces and polyhedra, both in their abstract dimension and in their architectural applications.

Notes

[1] The first edition of the volume was published in Bucharest in Romanian-language under the title *Probleme de reprezentare a structurilor constructive* [Gheorghiu, Dragomir1968]; an English edition of the work also exists, published in 1978 under the title Geometry of Structural Forms [Gheorghiu, Dragomir 1978].

[2] The translation of the text from French into English is by the author.

[3] In the book this construction is presented under a different formulation. The theorem in question is set out on p. 101, in the section entitled *Problèmes de fermeture sur un HR*, and states: "The successive reflections of any point in space with respect to a triangle traversed twice constitute a closed and well-defined form, in which the axes of symmetry are the generatrices of a single one-sheeted ruled hyperboloid.": Gheorghiu, Dragomir 1968, p. 101.

[4] The construction of the hyperboloid through three skew lines was also published in the Migliari 2009, Sect. 2.3.4, *The One-Sheeted Hyperboloid*.

[5] The issue lies in the fact that, within the current NURBS-based mathematical representation, no automatic function exists for generating a ruled surface defined by three given directrices. The surface can only be produced in an approximate form by interpolating the three prescribed lines; however, the resulting model is neither rigorous nor fully accurate.

Author

Federico Fallavollita, Department of Architecture, University of Bologna, federico.fallavollita@unibo.it

Reference list

Arnheim, R. (2009). *The dynamics of architectural form: 30th anniversary edition*. Berkeley: University of California Press.

Fallavollita, F. (2008). *Le superfici rigate e le superfici sviluppabili: una rilettura attraverso il laboratorio virtual*e. Ph.D. thesis in Scienze della Rappresentazione e del Rilievo, tutor prof. Riccardo Migliari. Sapienza Università di Roma.

Gheorghiu, A., Dragomir, V. (1968). *Probleme de reprezentare a structurilor constructive*. Bucarest: Tehnica.

Gheorghiu, A., Dragomir, V. (1968). *La représentation des structures constructives*. Paris: Éditions Eyrolles.

Gheorghiu, A., Dragomir, V. (1978). *Geometry of structural forms*. London: Applied Science Publishers.

Hilbert, D., Cohn-Vossen, S. (1960). *Geometria intuitiva* (Vol. 63). Torino: Paolo Boringhieri.

Migliari, R. (2009). *Geometria descrittiva*. Vol. II, *Tecniche e applicazioni*. Novara: CittàStudi.

Pottmann, H., Asperl, A., Hofer, M., Kilian, A. (2007). *Architectural geometry*. S.l. (Canada): Bentley Institute Press.