# Geometrical Walks in Architectural Space -

# The Synchronous Order of Geometry and the Sequential Experience of Space

**Volume one**

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## ABSTRACT

Architecture creates spaces to accommodate social relations. It also creates spaces to look at and experience through movement and through observation. In addition to social purposes some buildings carry an extra level of content. *This refers to the ways they become visually appreciated as spatial systems of a specific appearance.* These buildings are often thought of as works of architecture. It is on this additional dimension that this thesis focuses - *How works of architecture are seen experienced and interpreted as systems of cognition.*

Cognition depends on grasping a mechanism of construction; architectural composition is based on laws of construction. Cognition and architectural composition become, thus, intrinsically interrelated generating the need to look at composition as the source of architectural experience.

Architecture is subject to laws and these laws are expressed through two levels of systems. Architects combine geometrical shapes and forms to give buildings a specific appearance. They also combine spaces to give buildings a specific experience. *The ways in which geometry and space interact in the course of cueing and channelling the viewer's cognition of a building is the question addressed in this research. This is examined in the context of the architecture of Le Corbusier and Mario Botta.*

This thesis attempts to develop a common theoretical and analytical framework that studies the relationship between geometrical and spatial patterns. *It argues that formal and spatial description is a description of composition seen as a transformation process. This process progresses in stages from abstract-simple order principles to specific-complex ones. It also proposes that formal and spatial patterns interact through geometrical properties that stay invariant as an observer moves in space.* The more properties stay invariant the more these patterns coincide. (Botta). The less they remain invariant the more a tension is created between these patterns, (Le Corbusier). The former display a structural unity guiding and easing intelligibility towards a single reading. The latter present a structural complexity accommodating a multiplicity of readings.

The analysis of the two architects reveals also that there are two compositional directions. In the first one composition is dominated by an explicit syntax established at the first stages of the transformation process, (Botta). In the second one composition is dominated by a release of combinatorial possibility emerging during this process, (Le Corbusier). The former generates buildings that are grasped at once subjecting spatial narrative to formal pattern. The latter results in buildings that demand intense attention and extensive exploration making spatial procession the main protagonist of spatial experience.

The overall research concludes that architecture is based on a recognition of a composing strategy articulating the relationship between the synchronous geometrical order and the sequential experience of space.

## Foreword

*'Oedipus kills with words; he tosses mortal words into the air as Medea hurled her magic spells at Talos...Oedipus doesn't have a gorgon on his chest to defend him, doesnt' have the skin of a wild beast over his shoulders, doesn't have a talisman to clutch in his hand. Words grant him a victory that is so clean, that leaves no spoils. And it is precisely in the spoils that power resides. The word may win where every weapon fails. But it remains naked and solitary after its victory'*
Roberto Callaso, 'The Marriage of Cadmus and Harmony'.

If Theseus had met Oedipus before sailing to Crete his story might have been told in an another way. He would have neither needed Ariadne's thread nor would have touched Minotaurous. Lost in the turns and cul desacs he could rely on Oidipus' story and a device to draw. All he would need would be the drawing, the answer to the ainigma of the labyrinth that sent the Athenian youths to the darkness of Ades.

But as Callaso would say Theseus might have known what he realised later seeing Oedipus blind and beggar:*'the monster can pardon the hero who has killed him. But he will never pardon the hero who did not deign to touch him'.*

Or perhaps he might have known that drawings cannot give full answers. The labyrinth with its unexpected turns, its echoes, its smells of death and bountless fear could hardly step out from its image.

Or Theseus might have known that solving an ainigma like Oedipus would have condemned himself to darkness. Because *'The solution to an ainigma is thus itself an ainigma, and a more difficult one'.*

**Acknowledgements**

The formulation of this work into a doctorate thesis was possible through post-graduate studies but the origin, the interest and the inner drive developed on the drawing board when I was a student of architecture. Design was always providing the intuition and the inspiration until the final moments. Acknowledgements, therefore, are first to those who encouraged my interest from those early years, to my design tutors Aleka Monemvasitou, Anastasia Pehlivanidou, Iannis Liakatas and Mary Madouvalou and to my colleague Konstantinos Kakogiannis with whom I shared my enthusiasm and ideas. The second stage of this work grew out of my theoretical studies in the AAS Unit at UCL. Thanks are to all the present and previous members of this unit, Prof. Bill Hillier, Dr. Julienne Hanson, Richard Burdett, Alan Penn and particularly to my supervisor Dr. Julienne Hanson for her intellectual and organisational input, her trust and support. Thanks are also to Dr. John Peponis for his intellectual contribution during the stages in which the theoretical foundations of this work were produced; to the 'Onassis Foundation for Scholarships and Research' for funding my research in the first two years and waiting for me to complete for many years since then; to the Greek and German committee of EUROPAN I and III for giving me a first prize twice and contributing to the funding of this work; to my students in the University of Greenwich whose work enhanced my understanding of design. Thanks are also to my partner Dr. George Fatseas for tolerating my long term absence and my obsessive need for independence; to my friends Tamara Zivanoviz, Nelly Marda, Dr. Lena Tsoskounoglou, Tonia Noussia and Petounia Exakoustou for their friendship during the years of this work; to my friend Tony Mulhall for his large and diverse support and those intellectual discussions that encouraged scepticism towards inherited concepts and expanded my thinking; to Rea Psarra for being a practical, positive and supportive sister; to those who have found and will find this work of certain use; to those that driven by the power of the *naked word* enter the labyrinth unarmed; to those that cause this word innumerable deaths without acknowledgement. For these are the ones who pay it the greatest possible honour. And most of all thanks are to Eleni Psarra and Panayotis Psarras *for the Oedipus story and the rottring pens.*

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## Introduction



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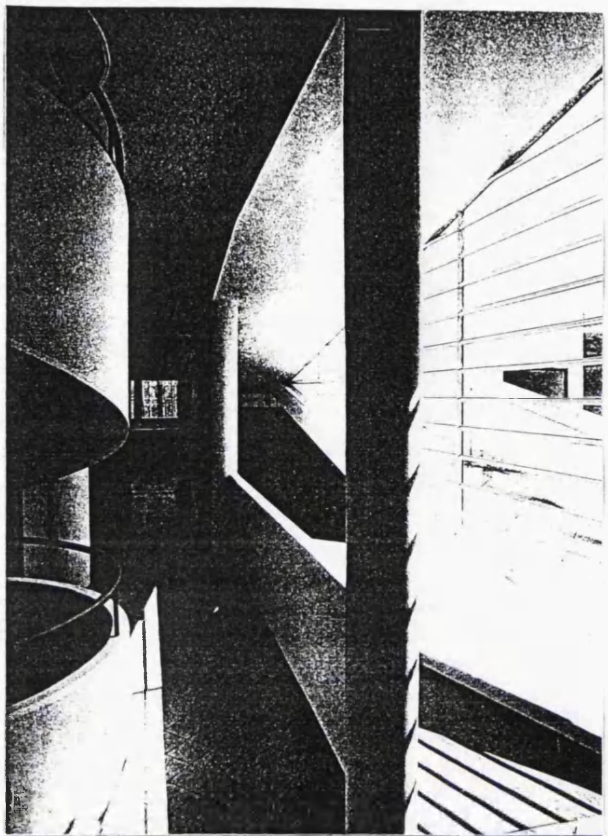
# INTRODUCTION



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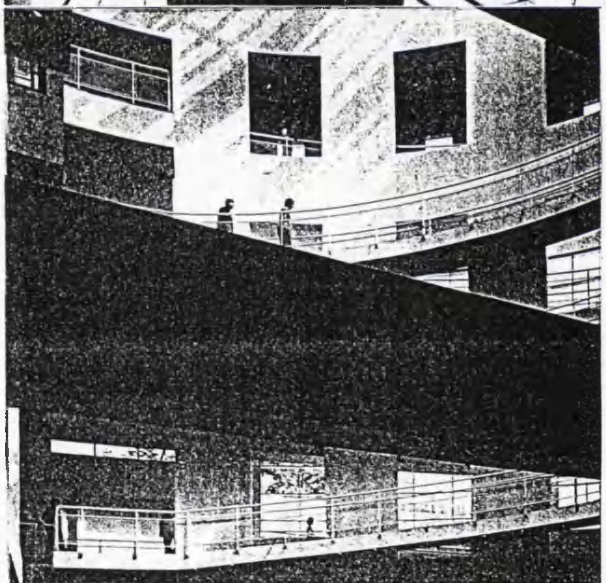

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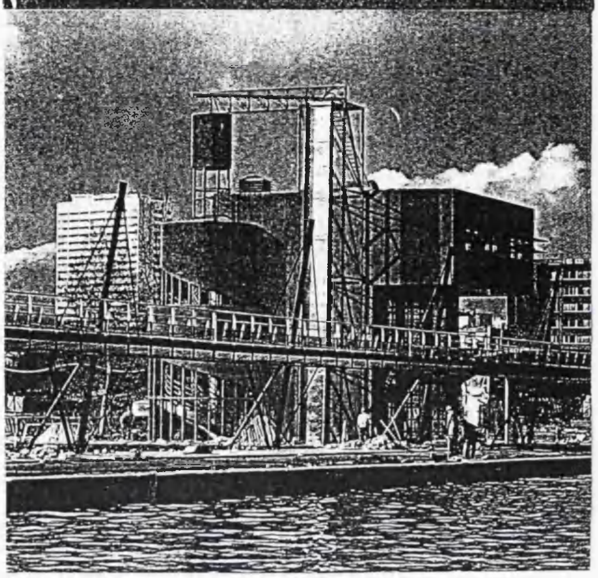

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## • THE RESEARCH PROBLEM

### • How buildings are seen and understood as physical artefacts

The very existence of buildings that are not merely used for social purposes but are also visually appreciated by their users posits the question of *how buildings are experienced as physical artefacts.*

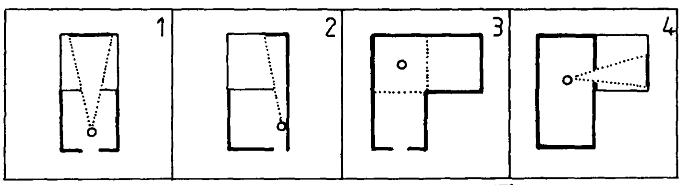
People often visit buildings for the sake of pure discovery and visual appreciation. Galleries and museums, for example, are visited not simply for the purpose of seeing a display but also for the enjoyment of participating in a spatial and social event in which the building's visual style is an important component.

This is often reflected in the ways architects are concerned with how their buildings can offer interesting vistas and spatial sequences. From Le Corbusier's conception of a building as a promenade arhitectural to Richard Meier's museum in Atlanta, with its emphasis on the circulation ramps as a celebrated transition from the ground level to the levels above, buildings are seen as threading spatial experiences together through the sculptural assemblage of masses and spaces into a form, (illustrations 1, 2). Bernard Tschumi's red pavilions in Parc de la Villette are the most contemporary examples in this respect declaring their usefulness as pure hedonistic gestures that attract the public with their mere physical existence and articulation, (illustration 3).

Some buildings, therefore, together with social purposes, function as spatial environments that arouse interest by virtue of their massing and spatial form. They stimulate the viewer to move through and see them from many points of view. It is the same interest that draws people to walk in urban settlements for the pure pleasure of seeing and experiencing on foot.

An urban settlement, though, is seen as emerging from the gradual and collective processes of a society without any overall pre-conceived plan or order. Cities have spatial patterning. However, this is not imposed by a mind seeking a logic that connects their spatial episodes into some sort of recognisable format.

Like cities, buildings are experienced through movement that links their spatial incidents together. Unlike cities, buildings are seen as *rule governed systems* intentionally applied by an architect who arranges spaces, surfaces and forms into an ordered pattern. In some cases this pattern takes the form of symmetry, rhythm, repetition and other kinds of geometrical regularity. In other cases, there is no evidence of regular geometry. Nevertheless, regardless of the degree of regularity, there is a system of control the architect imposes over the architectural components that constitutes an important parameter in spatial experience.

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Viewers might choose to move through a building, try alternative routes and points of view and use it as a container for their own purposes and systems of understanding. However, in spite of their private perspectives, there are particular ways the architect has orchestrated their experience. What they experience from within has been conceived from without and orchestrated on a drawing board through a system of rules. It is this orchestration a viewer might feel stimulated to uncover. This is also the question this thesis tries to answer.

- **THE RESEARCH QUESTION**

- **How the ordering patterns of buildings enter spatial experience**

It seems, thus, that buildings often solicit an interest from the part of the viewers by virtue of a noticeable external authority who composes shapes and spaces using some sort of underlying pattern. The question addressed by this study is :

*How the rules the architect uses on the drawing board, like symmetry, rhythm, repetition, to hold the architectural elements together are seen and grasped during spatial experience.*

It is important to say that not every building is connected with that peculiar interest aroused in the observer. Not every building absorbs and sustains attention as an interesting object of concern. Then the question of how buildings are seen and understood as rule governed physical objects involves a second question:

*What makes some buildings and not others interesting to look at and experience in this peculiar way?*

- **Drawings and buildings - Two different ways of seeing**

Starting with the first question it is essential to clarify what is meant by the system of rules that organise a building on a drawing board. It is also important to examine how these rules look in space. This can be possible by looking at some examples of elementary layouts presented in figures 1, 2, 3 and 4.

In figures 1 and 2 two bounded spatial rectangles are joint together to define a larger one. What groups them into this rectangle is the fact that their left and right surfaces are defined by a common line. It also the fact that their geometrical centres lie on the same axis. Figure 3 shows a concave spatial shape that can be described as a spatial L. If the lines defining the concave vertex are extended to intersect with the opposite surfaces two rectangles and a square are defined. The geometrical centres of each of the two rectangles and the geometrical centre of the square are covered by the same axes. Figure 4 is about two rectangles joined together in such a way that their top surface is aligned. There seems to be no other regularity in this layout.

It becomes apparent that what organises these layouts into recognisable shapes or forms is a co-ordination of their elements through a set of *geometrical principles.* So, it could be said that what the architect does is to arrange formal elements on a drawing board that are interrelated by some underlying *geometrical order.*

The notion of geometrical order is often associated with geometrical regularity, i.e. with those rules that define simple geometrical shapes like squares, circles, cubes or cylinders. To avoid exclusion of irregular patterns, which also possess an ordering logic, a broader term will be used. This is: *formal order seen as the set of properties that co-ordinate lines, shapes, surfaces and masses into a whole.* However, the relationship of formal order to geometrical order remains a question to clarify. This will be provided later through a description of the ways theoretical discourse has approached the notion of form and geometry[1].

Moving to how these layouts are visually experienced by an observer that moves inside them, an important difference between the perception of these layouts as based on these principles and their perception in real space arises. *The vision of a viewer that is anchored on the ground is constrained by his relative position in space. There is no place he can stand and see the whole at once. He continuously sees partial views as he moves around.*

Thus, the layouts in figures 1 and 2, (page 3), are seen as two separate enclosures rather than as two spaces that define a larger spatial rectangle. However, whereas in the first layout the two spaces are seen as separated from each other, in the second one they are seen as connected by a common surface. This surface seems to clarify their relationship and suggest that they are linked together into a larger spatial shape. The rule specifying that the two elements are defined by a common straight line, is experienced in reality through the physical presence of this line in the form of a boundary. In this case a formal principle becomes *explicitly present*[2].

In the first layout there is no explicit physical definition of a formal property. However, implicit physical definition is given to the axis connecting the two rooms by their geometrical centres as well as by the door entrances. So, the viewer can infer this line instead of seeing it represented on a surface. In this example a formal principle is *implicitly present.*

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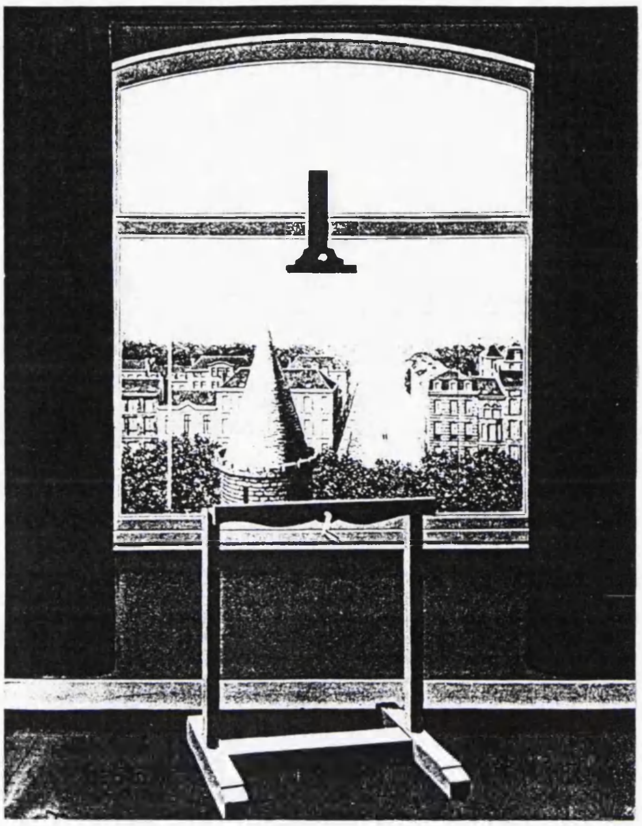
1 This is carried out in the following chapter which studies the position of the research problem in relation to an existing literature.

2 Previous work has suggested that figures 1, 2, (page 3), present two different modes of spatial/physical relation. These modes have been defined as 'boundary discontinuous' and 'boundary continuous'. Sophia Psarra, 'Internal and External Boundary Configuration, The Relationship between Elevation and Plan', MSc Thesis, AAS Unit, Bartlett School of Architecture and Planning, 1986.



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In figure 3, (page 3), formal properties are both implicitly and explicitly present. One standing in the area defined by the extended lines can see all the surfaces of the configuration. The lines defining this space in plan are physically present in the form of surfaces that are directly seen. Besides, the lines participating in the geometrical grid of the configuration are implicitly present. The viewer can infer them travelling across the space defining the area he stands in.

In figure 4, (page 3), the two spaces are firmly enclosed by boundaries that separate one from the other. Formal properties do not interfere in the experience of this layout. The observer cannot see how the surfaces of one room relate to the surfaces of the other at a single glance. While in plan the boundary relations are apparent, in reality they require movement from one room to the other to be understood. This seems the only way the viewer can combine the separate pieces of information each space transmits into a mental image of the configuration as a whole.

In the first three examples there is a coincidence of what is observed in plan and what is observed in reality. Formal properties are captured in both situations. In the fourth example properties are rendered synchronous only on the flat surface of the drawing. In reality they are never experienced simultaneously. These examples demonstrate that there is a difference between the world of shapes and formal pattern, as seen on a drawing surface, and the world as seen in reality. What is observed in a drawing does not always correspond to what is observed in space.

This split between representation and space reveals a fundamental difference between drawings and buildings. A drawing is not a building. It is a representation of a building. What it does is *to deceive by making one aware of relations that in reality can never be viewed as they are on a flat surface.*

This is also what paintings do. Looking at a painting one is aware of a three dimensional world, whereas the surface of the painting is flat. Some artists have exaggerated this deceptive property of paintings in their work. Margritte and Escher, for example, make reference to the simultaneous existence of two separate worlds on a flat surface, (illustrations 4, 5). In *'Les Promenades d' Euclides'* of Margritte the inside and outside spaces are rendered synchronous on the canvas represented on the painting. In the *'Still Life and Street'* of Escher interior and exterior are united by the surface of a windowsill that coincides with the surface of the pavement.

What is striking is that whereas the impossible worlds of these artists can shock and trap one's attention, the architectural representations may not produce any shock to the viewer. Accustomed as one is to reading conventional representations of layouts, he understands them as layouts rather than as a synchronisation of impossible relationships held together by the organising properties of formal order.

What drawings present is not the material facts of architecture as a series of intensive, partial and changing visual experiences. *It is a structure added to these facts through the principles of shape and* *form.* The difference between buildings and drawings seems, therefore, to capture the difference *between perception of architecture as a set of physical, material experiences that are anchored in the observer and the arrangement of these experiences into shape and pattern associated with the shaping strategies of the designing architect.*

A crucial observation that results from the above examples is that a full account of buildings relies on both their description as drawings with lines and shapes and their description as spaces with boundaries and openings. Volumes, spaces, surfaces and other architectural elements are translations of elements used in design like points, lines and shapes. So, it is through the study of the ways these elements feature in drawings and of the ways they feature in reality that the relationship between formal properties and spatial experience can be analysed and understood.

Based on these observations the research question can be reformulated in the following set of questions: *How do formal properties organise a building in architectural drawings? How do they organise a building in physical reality? Is there an explicit presence of them that adds comprehensibility to space? Is there an implicit presence so that they can be inferred rather than being directly seen, or is there hardly any presence of formal properties, such that the observer finds it difficult to organise the information he receives into a coherent visual form?*

**From drawing to building - From Classicism to Modernism**

Robin Evans observes also a difference between drawing and building. '... a plan is a set of geometrical operations on a flat sheet ... but the plan is no more a picture of the site than a triangle is a picture of a similar triangle'[3]. The Renaissance architects, Evans suggests, tried to make drawings and buildings pictures of each other. The axial routes passing through the axis of symmetry of a classical building shows up in the principal elevation as a principal entrance. One looking at this elevation can infer not only the symmetrical structuring of the plan but also the central sectional cut and the central procession passing though this line. The difficulty in visualising space through a drawing and visualising formal order through space was, thus, overcome. Building and drawing are captured in the most economical description and turned into a true representation of each other.

Philip Tabor sees also symmetry as a co-ordinating device that integrates plan, section and elevation into the same system. It also ensures redundancy by repeating the same principle everywhere. Thus, from the outside it prepares one for a symmetrical plan. 'Once inside the redundancy of symmetry simplifies the visitor's mental map of the building'[4].

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3 Robin Evans, 'The Projective Cast, Architecture and Its Three Geometries', The MIT Press, 1995, p. 113.

4 Phill Tabor, 'Fearful Symmetry', Architectural Review, May 1982, p. 23.

Using the authors' suggestions and the observations obtained from the figures examined before, it could be said that formal properties in classical architecture enter and clarify spatial experience in the form of an implicit presence. Similarly, spatial experience, an aspect of which is the processional axis of movement, enters the drawing in the form of an axis of symmetry.

In Classicism properties like centrality, symmetry and tripartition established a system that is applicable from the building as a whole to its smallest part[5]. Thus, the tripartite schema organising the plan, the elevation and section characterises also the vertical division of the classical orders into entablature, columns and crepidoma or stylobate.

'Each of these members is further divided according to the same schema. As a general rule, tripartition continues to be applied in the same hierarchical manner down to the most basic architectural particle, to the slenderest ripple of matter'[6].

What a viewer might notice looking at a classical building is not simply how the central route is expressed in the facade but also how the smallest detail is a representation of the total system of formal order. This relationship gives comprehensibility and brings formal order directly into the level of spatial experience.

Mario Galdesonas suggests that establishment of this language in Renaissance architecture marks one of the two moments in history where a new order was created sacrificing an older one.

'The establishment of a classical language and a theoretically organised practice of architecture in the Renaissance implied the death of the medieval architect builder who, in Alberti's definition, worked with his hands for the new rational architect who worked with his mind'[7].

The second moment is modern architecture in which the systematic and precise language of classical architecture was abolished for a looser, less explicit formal system. The suspension of this language as fashioned by the moderns opened the road to less clear rules, less clear shapes and a vast open field for combinations that moved away from symmetry, centrality and tripartite hierarchical organisation of parts.

'The idea of a transformational practice operating on a singular, well defined language was abandoned for research into the nature of language genesis itself. The rules represented in classical architecture by the order, the notion of beauty and rational Cartesian principles were abandoned and replaced with an ideology

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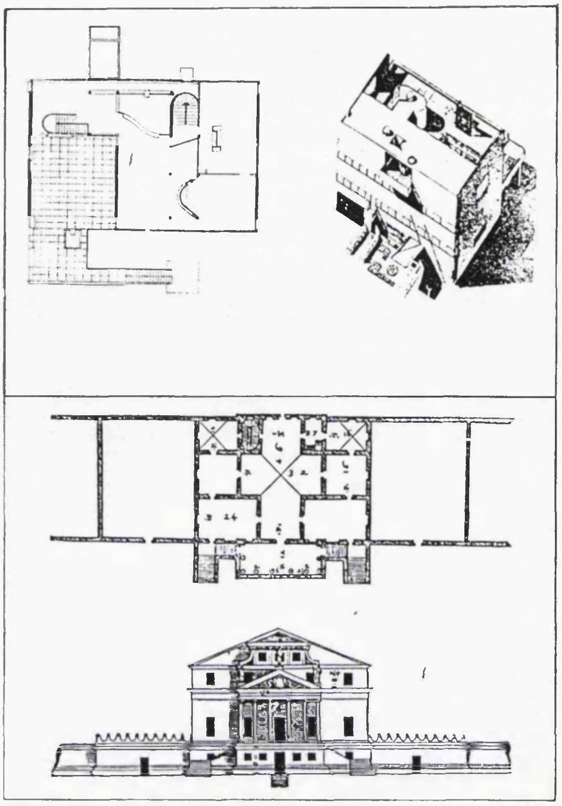
5 Tzonis and Lefaivre, 'Classical Architecture, The Poetics of Order', MIT Press, 1986, p. 43.

6 Ibid., p. 43.

7 Mario Galdesonas, 'From Structure to Subject: The Formation of an Architectural Language', in the book 'House X', Rizzoli International Publications, 1982, p. 7.



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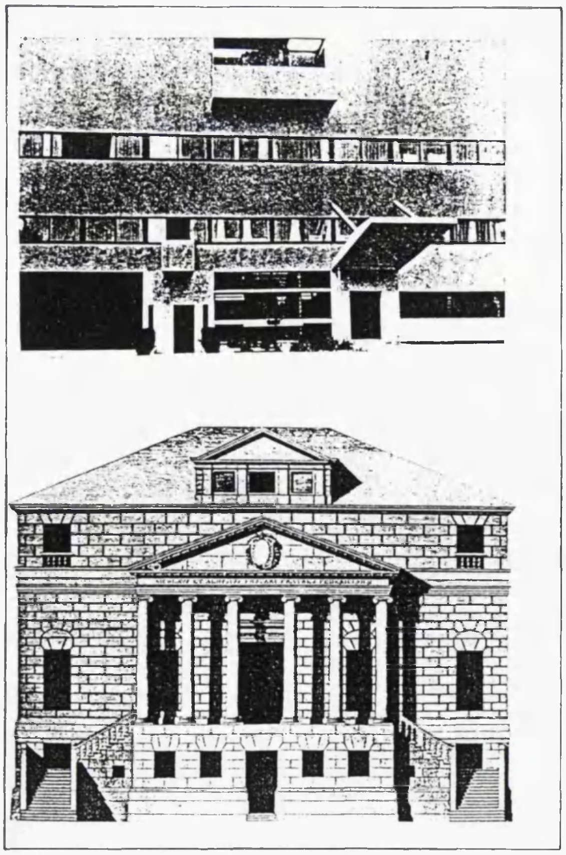

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that stresses the importance of relationships rather than shapes, leaving architecture with a highly diffused lexicon and an entirely new syntax'[8].

This change seems to have carried with it another change. Colin Rowe in a comparison between Palladio's Villa Malcontenta and Le Corbusier's Villa Stein demonstrates that the former presents the most clear and memorable manifestation of order through centrality and regular disposition of elements, whereas the latter presents a system that is focused only in terms of the geometrical organisation of its structural grid, (illustrations 6, 7).

'...thus, at Garches central focus is consistently broken up, concentration at any point is disintegrated, and the dismembered fragments of the centre become peripheral dispersion of incident, a serial manifestation of interest around the extremities of the plan'[9].

In the lack of focus in Villa Stein Rowe concludes:

'... from within, in the cruciform hall of the Malcontenta, there is a clue to the whole building; while at Garches, it is never possible to stand at any point and receive a total impression'[10].

Le Corbusier abandoning a clear and fixed system of geometrical regularity seems to have removed a clear manifestation of formal order from the experience of architecture. Another kind of spatial experience was established expressed in his announcement that architecture is appreciated on foot.

'Only on foot, in movement, you can see the developing articulation of architecture. It's the opposite principle to that of Baroque architecture which is conceived on paper, from a theoretical view point'[11].

The notion of movement as the intrinsic characteristic of modern architecture was also put forward by Sigfried Giedeon in his book 'Space, Time and Architecture' through an analogy of modern buildings with cubist paintings[12]. Giedeon transposed the fragmented character of cubism into architecture suggesting that there is no fixed view point but a collection of views obtained through time.

These differences between classical-modern, focused-dispersed, regular-irregular fixed view point-many view points seem to capture the difference pointed out by this study between drawing and building,

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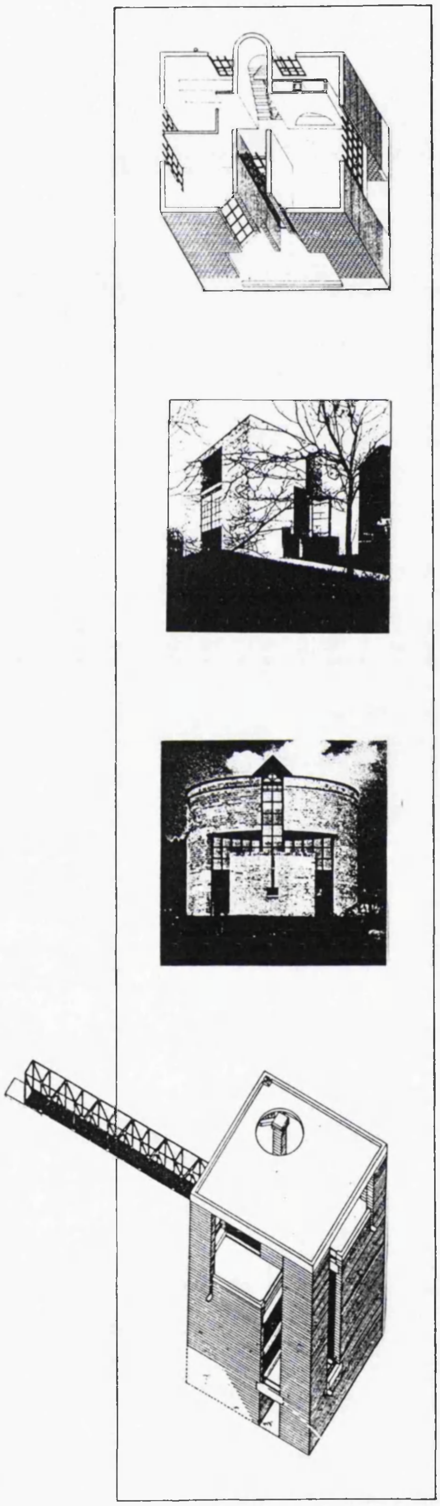
8 Ibid., p. 18.

9 Colin Rowe, 'The Mathematics of the Ideal Villa and Other Essays', The MIT Press, 1984, p. 12.

10 Ibid., p. 12.

11 Le Corbusier, Oeuvre Complete, II, p. 24.

12 Sigfried Giedeon, 'Space, Time and Architecture', Harvard University Press, 1967, p.p. 430-443



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between architecture as articulated by the principles of shape and form and architecture as experienced from the ground, between formal order that enters spatial experience and formal order that remains hidden.

- **From building to architecture**

In this context, the answers to the research question can be drawn from an analysis of buildings that accommodate these differences. From an initial point of view an analysis of classical and modern buildings seems appropriate to the question addressed by this research. However, a comparison between buildings coming from different historical contexts seems to have certain limitations.

Besides, a choice based on a classification of buildings according to combinatorial differences seems to dismiss some characteristics of classical and modern buildings which go beyond surface descriptions. This is because it provides oversimplified views ignoring certain subtleties and distinctions involved in the architectural production of a period.

Baroque buildings, for example, inspiteof their symmetries and regularities are often described as never allowing a privileged frontal point of view. 'They induce the spectator to shift his position continuously in order to see the work in constantly new aspects, as if it were in a state of perpetual transformation'[13].

Besides, some modern buildings display what is often described as 'balanced asymmetry' mostly expressed in a distribution of masses the weight of which is balanced to achieve a harmonious effect[14]. Colin Rowe points at a symbiosis of opposites in Le Corbusier's Villa Stein through the classical regular format of the grid and the irregular format of physical articulation[15]. Further, modern architects, like Mario Botta, develop clear and regular buildings within the ideological frame of modernism that abolished elements of cultural convention like the classical orders, (illustration 8).

The classification of buildings based on historic and combinatorial differences presents another difficulty. It seems to assume that architects are bound to the combinatorial modes of an existing period and of an existing architectural practice. The significance of this observation is in relation to the second question addressed by this thesis: *What distinguishes one building from another and arouses interest?*

This interest was defined as directed to the ways an architect arranges his volumes and masses and exposes them to the experience of an observer. It was also defined as a prolonged attention from the part of the viewer combined by a drive to read a shaping strategy. Attention is often associated with things that deviate from what is familiar to a culture through social convention. Ernst Gombrich suggests that attention is attracted by breaks in the continuity of perception, i.e. by breaks in things that are received

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13 Umberto Eco, 'The Role of the Reader', Indiana University Press, 1984, p. 52.

14 Philip Tabor, Ibid., p.p. 20-21.

15 Colin Rowe, Ibid., p. 12.

automatically grounded on the expected and the probable[16]. Gombrich using information theory as his background, grades attention according to a pattern's information potential, i.e. its capacity to carry degrees of surprise.

In this respect, the question of what distinguishes one building from another is a question of what distinguishes one particular building from ordinary buildings of everyday experience which the individual receives automatically as socially accepted cultural and physical environments. If a building is thought of as a mere result of cultural production the rules of which are known through familiarisation, then it has less chance of attracting the attention of the viewer.

One accustomed to the built products of a culture fails to notice such a building. This process of de-familiarisation was identified by the Russian formalists as constituting an essential feature of poetic language. According to them the essential feature of verbal art is that it de-familiarises language and renders its forms unusual[17]. De-familiarisation therefore, is associated with prolonged attention as well as with what makes a work of art. Roman Jacobson insisted that the unknown is comprehensible and striking only against the background of the known in a way that de familiarisation necessarily involves the past: the old automatized forms that serve as a backdrop to the new perception[18].

Reading a shaping strategy is also associated with works of art. Umberto Eco suggests that what distinguishes casual form from art is the fact that in the latter one reads the shaping strategy of an author[19]. Following these suggestions, it could be said that a work of art has the peculiar property of presenting unusual angles within a specific culture attracting attention directed towards its shaping strategies. In this context, the question of what distinguishes one building from another in this way is a question of what makes a building a work of architecture.

On this ground, a study intended to investigate the difference between architecture and building, should choose buildings *not for their potential to abide with a specific architectural period and practice but for their potential to go beyond the limitations of a specific architectural practice.* It should also choose buildings for their potential to show a concern for the ways in which their shaping strategies generate specific spatial experiences.

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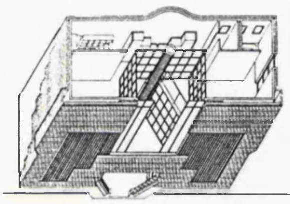
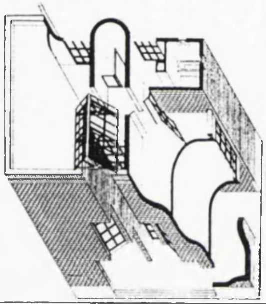
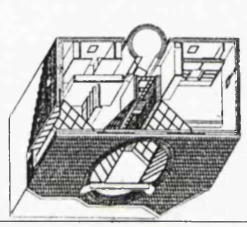
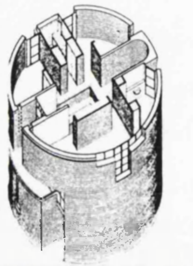
16 Ernst Gombrich, 'The Sense of Order, A Study in the Psychology of Decorative Art', Phaidon Press, 1992, p. 110.

17 Peter Steiner, 'Russian Fromalism, A Metapoetics', Cornell University Press, 1984, p. 216.

18 Ibid., p. 216.

19 Umberto Eco, 'Six Walks in the Fictional Woods', Harvard University Press, 1994, p. 116.

House at Viganello 1980–81 (9)

House at Pregassona 1979–80 (10)

House at Massagno 1980–81 (11)

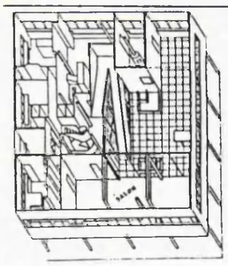
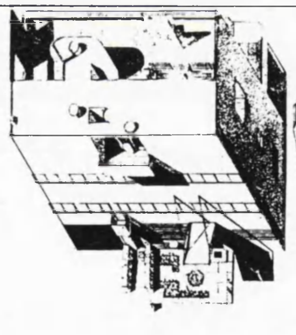
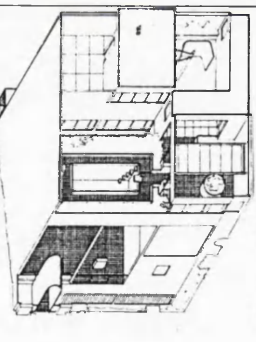
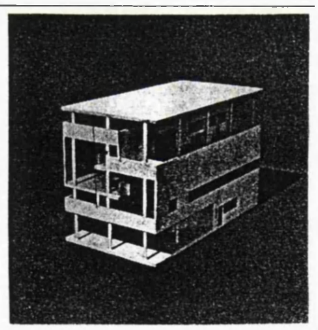
House at Stabbio 1979–80 (12)

Villa Savoie 1929 (13)

Villa Stein de Mongie 1927–28 (14)

Villa Meyer 1926 (15)

Villa Baizeau 1928 (16)

- **CHOOSING THE SAMPLE OF BUILDINGS - Eight houses by Mario Botta and Le Corbusier**

In this respect, a specific comparison that presents itself is that between houses of Le Corbusier and houses of Mario Botta. These are:

**MARIO BOTTA**

**1. House at Viganello,** (Canton of Ticino, designed and built in 1980-81). 2. **House at Pregassona,** (Canton of Ticino, designed and built in 1979-80). **3. House at Massagno,** (Canton of Ticino, designed and built in 1980-81). **4. House at Stabio,** (Canton of Ticino, designed and built in 1979-80), (illustrations 9-12).

**LE CORBUSIER**

**1. Villa Stein - De Monzie,** (Vaucresson, design of July 1927, built 1928). 2. **Villa Savoie,** (Poisy, design of 1929, built 1929). **3. Villa Meyer,** (Neuilly, design of June 1926, not built). **4. Villa Baizeau,** (Carthage, design of 1928, not built), (illustrations 13-16).

Looking at the villas of Le Corbusier and the houses of Mario Botta the two opposite tendencies are revealed - one expressing classical principles of form, the other expressing modern ones.

Botta's houses are simple volumes vertically excavated to define a recessed entry at the ground floor and open spaces at the floors above. The area of excavation occupies a central position on the elevation which is symmetrically organised on a vertical axis. Le Corbusier's houses are also simple volumes that are sculptured to accommodate terraces. However, there are cases in which the recessed areas occupy a side position, like at the back side of Villa Stein, and cases in which they occupy central ones, like at the front side of the same house.

Botta's interiors are also symmetrically organised around a central sectional cut that runs through the height of the house as a whole achieving symmetry in three directions. Le Corbusier's interiors are asymmetrical and vertically subdivided by the concrete slabs into horizontal layers that have a different organisation from each other.

- **A FIRST HYPOTHESIS - formal properties and spatial experience in Botta and Le Corbusier**

Botta seems to be characterised with extreme regularity and simplicity extending from the organisation of the volume and the elevations to the organisation of the interior and plan. Le Corbusier shows the opposite tendency favouring irregularity and complexity. In this respect, the comparison between these architects seems relevant to this research which is intended to investigate the difference between formal order and spatial experience across the contrasting characteristics simple-complex and regular-irregular.

The observations made above, which associate the regularity with a formal order that becomes retrievable during spatial experience, and irregularity with a formal order that remains hidden, can lead to the hypothesis: *Botta seems to enable an observer to grasp the organisation of form, whereas Le Corbusier does not.*

- **A SECOND HYPOTHESIS - Seeing Botta's and Le Corbusier's houses as works of architecture**

From a second point of view Botta and Le Corbusier seem also to incorporate opposite strategies. A large degree of critical attention devoted to these architects derives from a conviction that they both possess a creative power most clearly expressed in the assimilation of conflicting principles.

Le Corbusier is seen as a multidimensional architect who synthesised the most contradictory ideas of this world[20]. He is considered as an avant garde architect that opposed classical formalism and attempted to reorganise architectural thought. He is also seen as opposing functionalism, attempting to restore architectural thought. His five points developed in the early stages of his work are described as a departure from Classicism[21]. His Modulor developed during the later stages is considered as a reaction to Modernism[22]. At a time when modern architects rejected the classical tradition for technological functionalism Le Corbusier, it is said, displaced and reinterpreted both.

Architectural critics see Botta working in an period where Le Corbusier's creative powers have survived regardless of current changes[23]. In this period some of Le Corbusier's failures have shaken the ground of Modernism and demolished the need for common ideals. Botta has not attracted critical attention to himself to the degree that Le Corbusier has. However, scholars also present him as a reconciliator of conflicting strategies.

Botta, it is said, has combined classical simplicity with modernist abstraction through the massive blocks of his houses[24]. He has continued Le Corbusier's approach to light, orientation, climate and materials[25]. He has evoked Palladian nostalgia[26] through the sectional articulation of his volumes using symmetry, regulating lines and classical elements like loggias, verandas and vaulted skylights. At a time

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20 Robin Evans, Ibid, p. 276.

21 Alan Colquhoun, has seen Le Corbusier's work as involving around the displacement of classical concepts. Alan Colquhoun, 'Essays in Architectural Criticism', The MIT Press, 1985, p. 51.

22 Stanislauss Von Moos, 'Le Corbusier, Elements of a Synthesis', The MIT Press, 1979, p. 312.

23 Charles Jenks, 'Le Corbusier Tragic View of Architecture', Penguin Books, 1987, p. 7.

24 Robert Trevisiol 'Mario Botta, La Casa Rotonda', Edizioni L'Ebra Voglio, 1982, p. 82.

25 Francesco Dal Co, 'Mario Botta, Architecture 1960 - 1985', Electa 1985, p. 23.

26 Alberto Sartoris, 'Mario Botta, La Casa Rotonda', Edizioni L'Ebra Voglio, 1982, p. 85.

when the modern and the classical principles are re-examined and re-assessed, it is Botta's creative attitude to both that attracts critics to discuss and evaluate his work.

The synthesis of existing with new practices that reflects the creative powers of the two architects includes also their methods of construction in relation to their architectural forms. It is often said that Le Corbusier combined advanced technological construction with classical ideas of form[27]. It is also suggested that Botta combines the traditional load bearing construction with modern ideas of volumetric sculpturing and elimination of figurative form.

Le Corbusier's symbiosis of opposites extends also to the combination of the asymmetrical layouts of Modernism with the classical block and the symmetrical diagram of the support structure[28]. Botta's synthesis of antithetical principles includes the symmetrical layout of Classicism with the flowing space of Modernism and its absence of individual rooms. Le Corbusier employs regular structural grids, regulating diagrams and harmonic ratios showing an interest in the classical norms of composition. Botta creates a modern fluid space unrestricted by clear divisions of spaces as well as slight deviations from symmetry that accommodate the diverse elements of everyday living.

Architectural theory has seen these architects as working within a modern context of spatial planning taking also into consideration the classical tradition. Following these suggestions, it could be proposed that they are not restricted by a specific architectural practice. On the contrary, they seem to select amongst possible configurations creatively re-interpreting existing solutions. Gravitating towards both systems, these architects seem to attempt to make what seems intimately familiar, classicism and modernism, into something strange and unknown. In this respect, they attempt architecture through a concern for the ways their buildings can slip beyond conventional ordinary experience and the culturally accepted products of a specific architectural production.

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27 Alan Colquhoun, 'Modernity and the Classical Tradition', The MIT Press, 1989, p. 89 - 119.

28 Colin Rowe, Ibid., p. 2 - 17.

- **THE STRUCTURE OF THE RESEARCH STUDY**

This study organises its material into the following three parts:

| | |
|---|---|
| **PART ONE** | **A Theoretical and Analytical Framework** |
| Chapter One | **Literature Review** |
| Chapter Two | **A Model for Analysis** |
| **PART TWO** | **Analysis** |
| Chapter Three: | **Volumetric Analysis** |
| Chapter Four: | **Plan analysis** |
| Chapter Five: | **Spatial Analysis** |
| **PART THREE** | **A Discussion of Buildings as Works of Architecture** |
| | **Discussion** |

The contents of these chapters organising the development of a theoretical and analytical framework for tackling the research question, the development of the analysis of the selected buildings and its results are briefly described in what follows.

- **PART ONE - A Theoretical and Analytical Framework**

Part one attempts to establish a common theoretical and analytical framework for tackling the research problem. This is achieved by placing the study into a context of existing literature, (chapter one), and into a context of basic configurations, (chapter two).

- **Chapter one - Literature Review**

This chapter examines the existing literature identifying contributions and limitations in theories. These lead to a clearer definition of the research question, to the definition of the originality of this study and, finally, to a theoretical model for approaching the research problem.

The chapter is divided into three main parts. Part one examines the research question against theories specific to the architecture of Le Corbusier and Mario Botta. A number of initial conclusions are drawn concerning the ways formal order and its relation to architectural experience are approached by architectural discourse. It is argued that formal properties are about geometrical rules that organise the constituents of a building in a synchronous plane independently of the spatial position in which they are encountered in space. On the other hand, spatial experience is about those properties that are observed sequentially through movement in space, (spatial properties).

This leads to a re-formulation of the research question as follows: *How does the synchronous plane of geometry clarify relations observed sequentially in spatial experience?* A first hypothesis regarding the relation between these planes in Botta and Le Corbusier is formed based on the discussions of various authors: I*n Le Corbusier a tension between regularity and irregularity generates a tension between these planes. In Botta geometrical symmetry and unity creates a correspondence between them.*

Part two places the research problem into the context of a more general discourse seeking the basis of a suitable theoretical and analytical framework. This inquiry extends into theories of architectural composition, sensory observation and visual perception from the Renaissance period to modern times. The review of this material shows that theoretical discourse is divided between theories of composition and theories of how buildings look to the eyes of an experiencing subject. This split reflects not only the division between the architectural object and the experience of this object but also a lack of a theoretical and analytical framework in tackling the research subject. *In this context, the establishment of the theoretical and analytical approach that links composition, form and spatial experience defines the aims, the originality and the contribution of this research to the body of architectural knowledge.*

Ultimately, Hagen's proposition of visual perception as being geometrically determined through a series of invariants as an observer changes his position in space is identified as offering the greatest potential for providing such a framework. In addition to this it is argued: The question of how formal and spatial patterns are intelligible to the peripatetic observer carries with it the question of how they become intelligible to a composing architect. *Thus, a description of space and form should also become a description of composition.*

Finally, in part three a number of unresolved issues relating to the establishment of an analytical framework are addressed through an examination of recent theories of spatial and formal description. The issue of formal description is re-formulated *as a description of geometrical properties that remain invariant across a transformation process.* The theoretical framework behind this notion is group theory and its approach to geometry. This progresses from higher levels of order to lower ones defining structure as the set of properties that remain constant across the transformation[29]. It also enables analysis to trace back an object's genesis capturing the identity of an element by reversing the transformation. In this way, the description of form becomes also a description of a composition[30].

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29 For a description of group theory see Hermann Weyl, 'Symmetry', Princenton University Press, 1952, see also M. Hagen, 'Varieties of Realism', Cambridge University Press, 1986, and I Stewart and M Colubitsky, 'Fearful symmetry', Blackwell Publishers, 1992.

30 By a description of composition the operational processes giving rise to the building's form is meant rather than a temporal genesis of form.

Part three of the chapter concludes by identifying the basis for the development of an analytical model founded on the question: *Which are the formal properties that staying invariant as a person moves in space give access to the formal order of this space?*

- **Chapter two - A Model for Analysis**

This chapter examines elementary configurations with a view to developing a basic analytic model leading to a research methodology applicable to the analysis of real buildings. Following the proposition that formal properties and spatial properties should be examined separately and then in relation to each other, the chapter is divided into two main parts each of which examines each kind of properties.

Part one examines formal order transforming simple shapes to complex ones in stages. Based on group theory it defines formal pattern as what stays invariant in a transformation. This examination leads to the identification of three layers of properties: *properties of shapes*, *properties of grids* generated by the lines defining these shapes and *physical properties* characterising the relationships amongst their physical elements.

It concludes that: *formal order is about the ways in which each of these layers is structured as well as about the ways in which they relate to each other.* A co-ordination amongst these layers through common rules contributes to a single reading. Lack of co-ordination generates multiple readings and a structural ambiguity in interpretation.

In addition to this, a number of parameters essential in identifying simple order principles from more complex ones, together with the various stages in the transformation are identified. These include the parameter of scale and the notion of an economical description of properties. Thus, the research methodology can be based on a transformation that most economically takes a building from the abstract-simplest form down to its specific-complex form, from the large scale to the scale of its smallest detail.

Part two looks at spatial properties focusing on patterns of visibility created in space as well as on the geometrical and physical characteristics of these patterns. This examination leads to the development of a key analytical concept as accounting for the ways formal properties are grasped during spatial experience. This is *the overlapping space modelling* defined as a technique that draws the intersections of convex spatial elements on a plan. The overlapping elements generated by these intersections define the integration of visual fields produced from different convex spaces. They also define the exposure of surfaces that constitute convex spaces as well as the underlying network of grid lines that establish interconnections amongst these surfaces. In this way, a single analytical tool describes the visibility field, the physical definition of this field by boundary walls and their formal skeleton.

*The significance of overlapping space modelling is that it creates an homology between configurational tools used in analysis and compositional tools used in design.* A research methodology based on this homology is developed that *brings notions that designers intuitively use into the realm of conscious debate linking composition, formal and spatial description.*

This examination enables the development of a first observation regarding the ways formal properties relate to the spatial ones: *The more spaces are covered by overlapping elements the more physical and geometrical regularity is built into the structure of visual information co-ordinating visual fields and allowing access to formal order.*

- **PART TWO - Analysis**

The sample of buildings is analysed first in terms of their formal structure independently of an observer's existence in space, (chapters three and four), and second in terms of their spatial structure from the point of view of an experiencing subject, (chapter five). Comparisons across the two kinds of analysis drawn at the end of chapter five enable the examination of how formal and spatial patterns interact. Each of these chapters is structured in three parts. The first two parts look at each of the two architects, while the final one concentrates on a comparative examination between them.

- **Chapter three - Volumetric Analysis**

This chapter applies the analytic method in analysing formal properties to the external volumetric articulation of the selected buildings. It leads to the conclusion that in Botta there is a single rule organising the volume as a whole in relation to shape, grid and physical properties. In Le Corbusier there is more than a single rule applied to each horizontal floor and to each layer of properties. The effects of these differences in intelligibility are as follows: *Botta creates a unity of perception based on a static appreciation. Le Corbusier creates a multiplicity of perception based on a dynamic exploration.*

These observations are further elaborated by the identification of two modes of volumetric transformation. Botta employs a preservative mode applying rules hierarchically from the abstract to the specific state and from the largest to the smallest component. Le Corbusier develops a preservative and an obliterative mode in which the properties of the largest volume are alternatively applied and suspended.

This discussion extends into the area of the compositional logic of the two architects to show that *a preservative mode leads the design in process towards the realisation of a pre-conceived idea. On the other hand, a mode that oscillates between preservation and suspension of rules explores formal possibilities emerging during the design process which are controlled rather than directed by pre-established formulas.*

- **Chapter Four - Plan Analysis**

This chapter extends the analytical method into the examination of the plans. Relating the results of this analysis to the previous one, this chapter concludes that in Botta rules are applied hierarchically from the exterior to the interior and from the largest volumetric component down to the smallest element of the plan. In Le Corbusier exterior and interior are independently treated creating a dissociation between the two. A systematic preservation of rules in Botta results in a single reading exemplifying a compositional logic based on pre-conceived knowledge of a building form. A lack of systematic preservation in Le Corbusier generates a multiplicity of readings affected by a compositional process that encourages combinatorial freedom.

The analysis of the two dimensional surface of the plans is extended into an analysis of the three dimensional space they depict. The principal focus is to seek the pictorial potential of these plans to suggest spatial experience. This inquiry shows that Botta creates a tripartite organisation of implied depth expressing a symmetrical and tripartite organisation of space. Le Corbusier creates a simultaneous suggestion and compression of pictorial space in a cubist manner expressing the contradictions of architectural depiction on a flat surface. This analysis ends with the hypothesis that the canvas of their plans becomes a visual metaphor of spatial experience.

- **Chapter five - Spatial Analysis**

With this chapter the research reaches its final goal. It focuses on the spatial organisation from the point of view of a peripatetic observer and on the ways this interacts with the formal properties described in the previous chapters. Based on the theoretical proposition that spatial properties and formal properties are related through physical and geometrical characteristics that remain invariant in the transformation caused by the observer's movement in space, it studies spatial organisation in terms of visibility patterns independently as well as in relation to these characteristics.

A number of conclusions are drawn that demonstrate that spatial experience in Botta is static, deterministic and continuous. In Le Corbusier it is dynamic, probabilistic and discontinuous. The former results in a static appreciation of similar spatial episodes that occur in a pre-structured way maintaining visual connection with each other through overlapping visual fields. The latter creates a dynamic exploration in which spaces are encountered randomly and appear less inter-connected and different from each other.

These observations are extended to suggest that in Botta there are invariant global scale characteristics in the course of transformation of visibility fields, whereas in Le Corbusier there are only local characteristics that remain invariant. The results, this chapter concludes, are a spatial experience bound to formal order in Botta and one that takes a different direction from formal properties in Le Corbusier.

Similarly to the observations put forward in the previous chapter, this analysis suggests that the above are affected by two different modes of transformation encapsulating two different modes of composition. The preservative-obliterative distinction characterising the differences between the two architects is interpreted as a probabilistic-deterministic design process. In the former the sequential experience of space is overridden by formal demands. In the latter the synchronous organisation of form is subjected to the requirements of spatial experience.

This chapter extends the discussion towards the kinds of viewing the two architects create. It suggests that both architects arouse interest directed towards their shaping strategies either by a logic that exposes these strategies or by a logic that delays their exposure. In Botta viewers might not feel stimulated towards a prolonged exploration having their interest for intelligibility immediately satisfied. In Le Corbusier viewers might be continuously driven to carry on spatial exploration stimulated by a number of open interpretations that change and shift levels as the explorations unfolds. Observing a difference between a spatial experience displaying these characteristics and ordinary spatial experience, this chapter ends by setting a basis for a theoretical discussion of whether their buildings are works of architecture.

- **PART THREE - Discussion**

Reaching its end this study summarises its main arguments reaffirming the hypotheses established in the theoretical and analytical chapters.

- An analysis of form, space and their relationship is an analysis of composition seen as a dynamic transformation process.
- Spatial properties and formal properties interact based on invariant formal characteristics observed during the transformation of visibility fields as a viewer shifts his position in space.
- The more properties are applied hierarchically from the large to the small scale articulation the more formal order enters spatial experience. The less hierarchy is applied the less it becomes directly exposed requiring movement, mental effort and generating a multiplicity of interpretations.
- The architect and the viewer are complementary entities constructing each other in the course of design and spatial experience. The architect articulates the ways in which his buildings are viewed. The viewer reconstructs the architect's shaping strategies discovering the ways he has planned his spatial experience.

The discussion is extended to address the question of what distinguishes architecture from ordinary buildings arousing a prolonged attention and an interest to uncover the designing strategies of the architect. It is suggested that architecture is recognised when there is a constructive and innovative strategy operating within a field of combinatorial possibilities articulating the relationship between the serial and the synchronous organisation of space.

In addition the discussion extends into the innovative potential of the two architects suggesting that both create new ways in which the serial and the synchronous planes are combined within the classical and modern architectural practices. However, Botta reduces combinatorial freedom directing space and form to satisfy the familiar patterns of a simple concept. Le Corbusier releases combinatorial possibility creating a multiple distribution of elements into many relationships that incorporate and challenge culturally familiar patterns. This release of possibility cannot settle down in a single meaning generating new points of view. This discussion extends to examples from other areas of art suggesting that works displaying a combinatorial logic of this kind are directed towards maximisation of innovation entailing a larger poetic potential.

# Part One

# A THEORETICAL AND ANALYTICAL FRAMEWORK

# Chapter one

# LITERATURE REVIEW

- # INTRODUCTION

- **How architectural discource sees the relationship between geometry and space**

In architectural theory geometry occupies a dual position. On the one hand, it has been central to theories dealing with composition and the constructive powers of geometrical shapes and ratios. On the other hand, it has been peripheral to theories that deal with what makes itself available to vision. In the former geometry is the generative force. In the latter it is an abstract force that tracing lines on a drawing board is removed from spatial experience. The question that is raised here is: *How a revision of the literature can clarify the ambiguous position of geometry and its relationship to spatial experience?*

Besides, if the dubious position reflects a division of architecture seen as construction and architecture seen as perception then the question that is raised here is: *How the constructive powers of geometry enter perception?*

The problem of how architecture is given shape and form and how this is experienced in space raises also the question: *How geometrical-formal properties can be analytically described?* The fundamental assumption made is that it is not possible to talk about architecture prior to a systematic description of its laws.

The above questions are investigated in the light of a comparison between Le Corbusier and Mario Botta. Thus, the description of their work is a second theme that runs parallel to the above issues. The objective of this chapter is, therefore, threefold:

- First, to examine how the existing literature sees the relationhip between the formal and the observable properties in the architecture of Mario Botta and Le Corbusier.
- Second, to examine how the problem addressed by this research relates to a broader theoretical discourse regarding intelligibility in architecture.
- Third, to examine the ways various authors tackle this problem from an analytical point of view.

Apart from placing the subject of this research into the context of existing theories the aims of this chapter are also:

- Through a critical review of theories to achieve a clearer definition of the research question.
- To establish useful contributions of these theories to this question.
- Finally, to identify possible weaknesses in the various theoretical accounts and in this way to define where the contributions and the originality of this study lie.

In what follows a summary of the ways this chapter organises its material and its main arguments is offered.

The chapter is divided into three main parts. Part one examines how existing theories see the relationship between formal properties and spatial experience in the architecture of Botta and Le Corbusier through eight binary oppositions evolving around the notion of form. This examination leads to the suggestion that *formal properties are about geometrical properties organising a building in a synchronous plane, while spatial experience is about properties that are sequentially perceived in real space.* In this context, the research question becomes a question of how these two planes interact. A first hypothesis is formed regarding this interaction in the buildings of the selected architects: *In Botta the two planes correspond, while in Le Corbusier they are in tension in relation to each other.*

Part two extends into the area of a more general discourse seeking the basis of a theoretical and analytical framework which can serve in tackling this problem. This review shows that theoretical discourse is divided between theories of the architectural object and theories of how this looks from the eyes of an experiencing subject. *The establishment of a theoretical and analytical framework in tackling this split defines the aims, the originality and the contribution of this research to the body of architectural knowledge.* The basis for this framework is given by Hagen's proposition that visual perception is geometrically determined through a series of characteristics that stay invariant as an observer changes his position in space.

Part three concentrates on recent theories of spatial and formal description with a view to develop an analytical framework capable of accounting for the research question. Using group theory's approach to geometrical description, this discussion argues that formal properties are that set of *geometrical properties that remain invariant across a transformation process.* This process progresses from higher levels of order to lower ones enabling also to trace back an object's genesis and capture the identity of an element by reversing the transformation. In addition to this, it is argued that the question of how formal and spatial patterns are intelligible to an observer is a question of how they are intelligible to a composing architect. *Thus, a description of space and form becomes also a description of composition.* In this context, research argues that the basis for the development of an analytical model is founded on the question: *Which are the geometrical properties that staying invariant as a person moves in space give access to the geometrical order of this space?*

# PART ONE

- ## FORM AND INTELLIGIBILITY IN THE ARCHITECTURE OF LE CORBUSIER AND MARIO BOTTA

- ### Creative assimilation of opposites attracts attention of theorists

There is often a belief that Le Corbusier is one of the most influential architects of the century. There is often a belief that Mario Botta is one of the contemporary architects who continues the 'Corb revival'[1]. Le Corbusier's design principles recorded in contemporary buildings like those of Mario Botta and in contemporary writings are often seen as a demonstration of a persistent strength[2]. A large degree of critical attention devoted to Le Corbusier and Mario Botta results, thus, from a belief that *their work presents the most fundamental principles of modern architecture.* In was suggested earlier that the fascination by which critics approach these architects derives also from a conviction that *they both possess a creative power most clearly expressed in the assimilation of compositional opposites.*

This shared belief in the creative attitudes of both architects who transform existing practices and unite conflicting strategies have inspired a number of interpretations. These focus on the role of opposites as a way to measure their creative strength and discuss their architectural logic, and often take the form of binary oppositions between concepts.

The following section presents eight of the most influential opposites through which the work of Le Corbusier and Botta is approached in relation to the notion of architectural form[3]. In the beginning of this thesis form was defined as referring to the ways architectural elements come together in an organisational system to make a building. It was also seen as being associated with geometrical order governing relations amongst shapes, lines and other geometrical elements.

In this context, the aim of this part *is through the ways authors discuss architectural form to uncover the ways they approach geometry*. It is also to cover the questions addressed by this thesis: *What is the relationship between formal-geometrical order and spatial experience in the architecture of Le Corbusier and Botta? Which is the role this relationship plays in the intelligibility of their buildings?* Finally, the aim *is to draw some observations for the development of a theoretical and analytical approach to these*

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1 Charles Jenks, 'Le Corbusier Tragic View of Architecture', Penguin Books, (N. Z.) Ltd, 1987, p. 7.

2 Charles Jenks, ibid., p. 8.

3 It is not intended to imply that these opposites are the key to the whole of a theorist's architectural ideology. In some cases they are selected from their writings as representing parts of their arguments. Reference to their contradictions will be also made as a means to offer an objective view of their position in architectural theory. Besides, the list of opposites aims at presenting the assumptions, misconceptions or contributions in a body of theory rather than in the small context of a particular writer.

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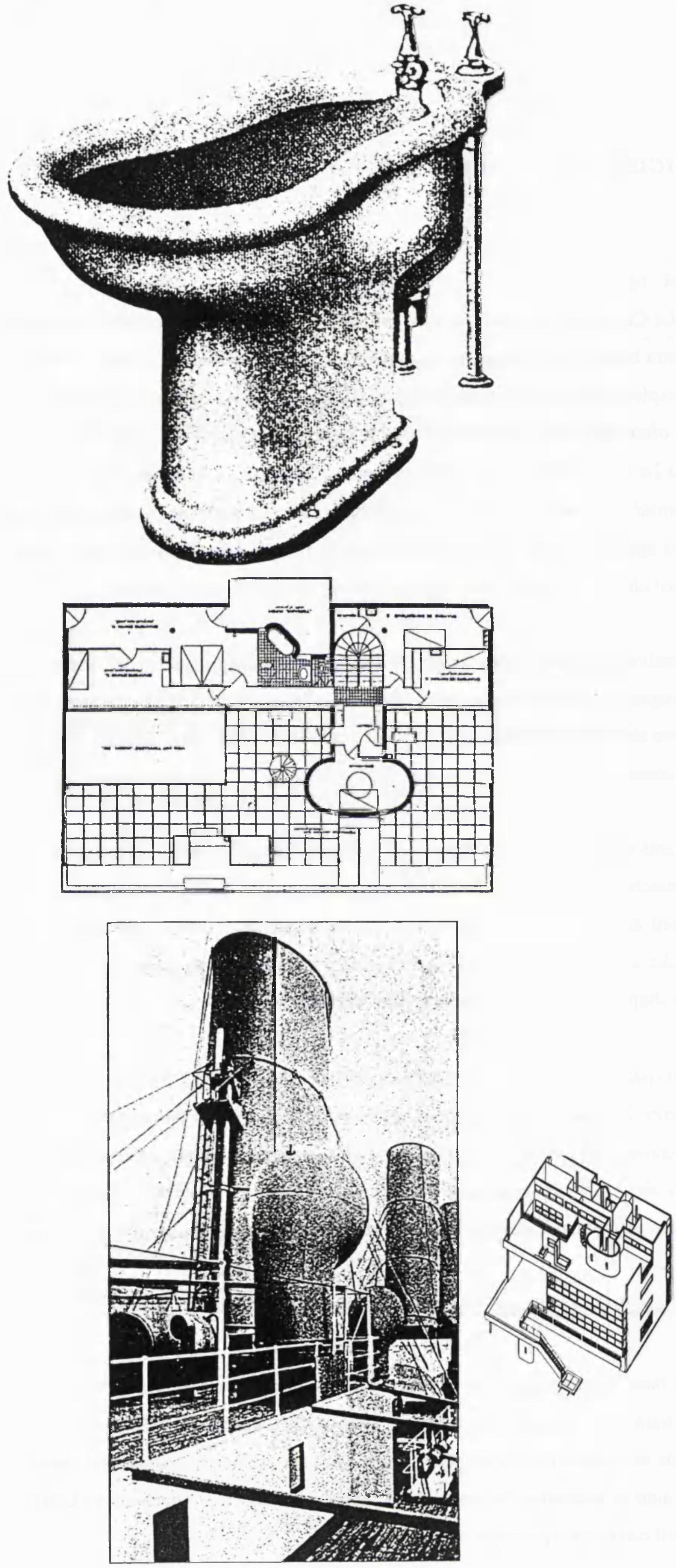

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*issues*. The theoretical significance of these observations will be tested at the following part which examines the subject of this research within a broader theoretical context.

The binary oppositions through which the two architects are approached by various theories are categorised into two sections: the first section is about oppositions between the notion of form and the notion of social signification, (form-iconic reference, form-function, form-self referential sign). The second part is about oppositions within the notion of form itself, (Proportional-Platonic form, geometrical-physical form, actual-shallow form, actual-projective form, generic-specific form).

- **THEMES FOCUSING ON SOCIAL SIGNIFICATION**

- **Form and iconic reference**

One of the most influential interpretations of Le Corbusier's architecture is based on phenomena it evokes outside itself. In a comparison of Palladio's Villa Malcontenta, with Villa Stein Colin Rowe suggests that Palladio's *piano nobile*, wall, pediment, entrance front and roof and Le Corbusier's sitting room, facade, front terrace, garden terrace and roof are linked together by organisational differences as well as by analogy and metaphoric substitution[4].

While Rowe limits such observations to Villa Stein, Alan Colquhoun generalises them to include what Le Corbusier defined as the compositional principles of his work, the 'five points'. For Colquhoun these result from a displacement of classical elements[5].

The second kind of displacement both Rowe and Colquhoun recognise, refers to elements outside 'high' architecture. Fragments of vernacular and monastic architecture, elements of *'poshe'* spatial planning, of the technological word and industrial architecture, are all assimilated and metaphorically absorbed in Le Corbusier's buildings[6].

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4 Colin Rowe, 'The Mathematics of the Ideal Villa and Other Essays', The MIT Press, 1984, p. 6, 7.

5 Colquhoun considers the *pilotis* as a displacement of the classical podium. The *fenetre en longeur* as a substitution of the classical window aedicule. The *roof terrace* as replacing the attic storey with an open air room. The *free facade* as exchanging the classical wall pierced by windows by a free composition. Finally, he sees the *free plan* as replacing a layout constrained by the load baring walls with a layout in which the internal partitions are freed from structural supports. There is, thus, an implicit proposition that if this is what the five points do, and if the five points summarise Le Corbusier's architecture, this is what Le Corbusier's architecture is about. Alan Colquhoun, 'Essays in Architectural Criticism', The MIT Press, 1985, p. 51.

6 Examples of these elements are the Catalan vaults, the Carthusian monk gardens, the Parisian hotel's corridors and rooms, elements of technology like ocean liners and industrial places like warehouses, silos and factories, (illustration 1.1). Alan Colquhoun, ibid., p. 51-66.

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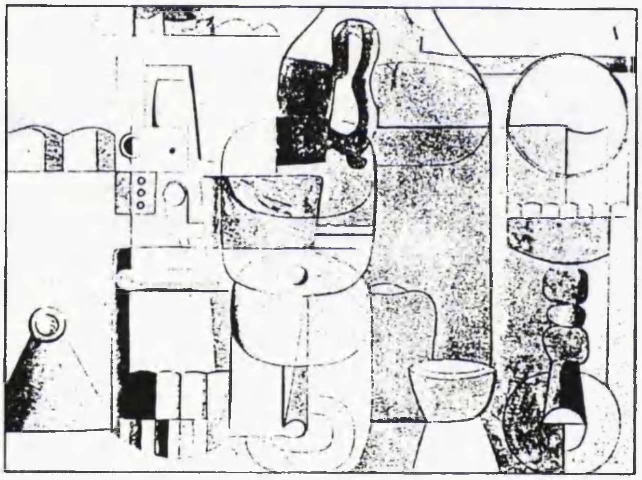

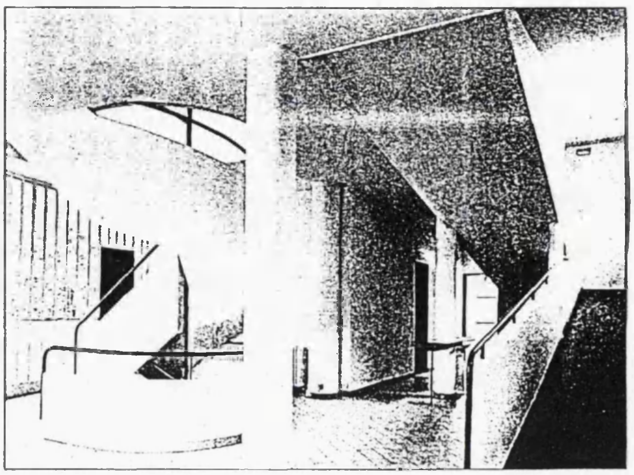

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Colquhoun suggest that Le Corbusier incorporates also concepts from other areas of art. In his paintings 'object types' like bottles, guitars and pipes, are transformed to architectural elements like staircases, closets and passages. There is a formal kinship between the organisation of the painting and the house. This is based on a 'Platonic regular frame' and on the 'hollow containers whose curved convex surfaces project into, and interlock with, the neutral field'[7], (illustration 1.2).

Colquhoun constantly points at the ways Le Corbusier's architecture carries meanings outside itself. His five points refer to classical elements not present in his work. His vaults, religious forms, ramps, decks and roofs refer also to elements extrinsic to his architecture. Thus, Colquhoun's description is *a description of things Le Corbusier's buildings refer to, rather than of things they consist of*.

Things are evoked *'in absentia'* through their metaphoric transformation into something else. The five points are architectural elements or systems of elements[8]. Vaults, staircases and ramps are also individual elements, like the figures in his paintings. Whenever Colquhoun looks at things inside architecture, he looks at elements or sub-systems of elements in isolation rather than at how they are incorporated into an organisational system.

Thus, priority is given not to how they come together but to how they communicate and transform cultural meanings through social convention. In another essay Colquhoun suggests that architecture is an interaction of *forms* and *figure*[9]. *Form* is a configuration that is devoid meaning. *Figure* is a configuration whose meaning is given by culture. If architecture carries meaning only through figures it is only through the ways Le Corbusier transforms existing figures that an understanding of his work is possible.

However, Colquhoun gives a contradictory statement referring to a building as 'a conceptual and spatial unity that imprints itself into the mind'[10]. In other instances he suggests that Le Corbusier's houses are descriptions of the structure of architectural space as Cubist paintings were descriptions of the structure of pictorial space[11]. Formal characteristics like the rectangular frame and the interlocking curves explain how stairs and ramps are icons of guitars and pipes. Thus, although meaning derives from figures, it also derives from formal operations. As though anxious of his own contradiction Colquhoun quickly

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7 Alan Colquhoun, 'Modernity and the Classical Tradition', The MIT Press, 1989, p. 170.

8 Whereas the fenetre en longeur can be seen as an element in isolation, the rest of the five points, i.e. the pilotis, the roof terrace, the free facade and the free plan are systems consisting of elements that enter in a set of relations. However, they are sub-systems within the total system of the building as a whole.

9 Alan Colquhoun, 'Essays in Architectural Criticism', The MIT Press, 1985, p. 190-202.

10 Ibid., p. 55.

11 Ibid., p. 62.

proposes: 'In considering this figural system, formal analysis must give way to an analysis of content and meaning'.

Stanislauss von Moos examines Le Corbusier from a similar point of view. He suggests that the 'five points' are combinations of form, function and 'machine-age symbolism'[12]. Regardless of the interaction of three parameters, it is the last two that attract von Moos' attention. Of these two, function served as a disguised pretence, as a scientific explanation for forms charged with symbolism[13].

Von Moos concludes that the 'five points' are sufficient to understand Le Corbusier's formal language. As 'isolated factors', though, they are insufficient to reconstruct its framework. While Colquhoun proposes a distinction between form and figure, Von Moos proposes a distinction between deriving meaning from a language and reconstructing its framework. However, both see Le Corbusier's architecture as being about a distinction of *meaningless form* and *meaningful figure.*

For certain authors Le Corbusier's architecture refers not only to individual components but also to fragments of a classical canon. Alexander Tzonis and Liane Lefaivre suggest that Le Corbusier employs classicism 'as means of questioning a dogmatic or quasi-dogmatic, routine application of the classical order'[14]. In Villa Savoie and in Chandigarh certain facets of the classical taxis, (the grid and tripartition), and symmetry are applied, others are violated while the 'genera', (the classical orders), are ignored.

This approach first identifies classical schemata as isolated portions of a total body of relationships and second it looks at what these schemata speak about. Thus, from Colquhoun and von Moos to Tzonis and Lefaivre a shift from *meaningless form* to *meaningful geometrical pattern* takes place.

In certain cases the overall form of a building can also be turned into a reference. Robert Trevisiol proposes that Botta's 'purified', elementary forms refer to an abstraction that subscribes to the Modernist tradition and its 'precursors'[15]. Botta's connection with historic heritage extends also to include forms 'that man can control' and through which he can recognise himself. These elements have the ability to speak about the past and this is how one finds them familiar.

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12 Von Moos argues that *the pilotis* was a form of visual isolation from the ground, of functional stratification, of symbolisation of a universal architecture without roots and of historical protest against the classical buildings rooted to the soil by heavy podiums. Similarly to the pilotis the other points develop from a formal, functional and symbolic considerations. Stanislauss Von Moos, 'Le Corbusier, Elements of a Synthesis', The MIT Press, p. 69-74.

13 Like Colquhoun von Moos sees this symbolism as referring to the reaction against the academic tradition, to the bourgeois life, to the Mediterranean forms, to ocean liners and factories, ibid., p. 69-74.

14 Alexander Tzonis and Liane Lefaivre, 'Classical Architecture', The MIT Press, 1986, p. 280.

15 Robert Trevisiol, 'Mario Botta, La Casa Rotonda', Edizioni L'Ebra Voglio, 1982, p. 82.

Trevisiol suggests that Botta's architecture is concerned also with its own 'structure' expressed by the geometrical clarity of the plan. There is, thus, a duality at work between structure and historical reference. The key element to structure is the geometrical clarity of the plan and its constructional process. The key elements to history is the overall form seen as a single solid and fragments of forms, like the figure of the skylight. Therefore, with Trevisiol the form-figure duality has been turned to a space, (plan)-form duality. Space is a constructional process. Form, the building's overall shape, speaks of Modernism. It has been turned to a figure itself.

A number of other references are read in the overall form of Botta's buildings. Kenneth Frampton finds that it refers to the Ticino landscape[16]. It harmonises with the topography by analogical reference to building types, 'the traditional tower like country summer houses', the silos and the barn-like shells. For Frampton the existing structures of the region serve as prototypes of the overall form. This form turned into a content, a building 'type' is also a figure, a fragment of the cultural landscape. For Trevisiol and Frampton meaning in Botta's architecture is external to his building carried by the ways the modern architectural practice or the traditional architecture of the region has interpreted its overall shape.

- **Form and function**

Evans suggests that Le Corbusier himself used oppositions to define his work[17]. One of these oppositions is architecture as the '...magnificent play of volumes assembled in light'[18] and architecture as function, engineering and technology. Intrigued by this contradiction a number of critics examine his work in terms of the relationship between form and function.

Colquhoun observes not a dichotomy, as Le Corbusier presents it in his writings, but an interaction[19] between these concepts. This is expressed through the classical order of the exterior and the complex informality of the interior. The simple 'Platonic' volume expresses the formal-classical theme, the 'primary experience of geometrical solids seen in light'[20]. The regular structural grid expresses also the classical order. This order is hidden behind an irregular surface the openings of which express the practical organisation of the plan. It is this surface '...bounding the volume which, properly speaking, constitutes architecture'[21].

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16 Kenneth Frampton, 'Modern Architecture, A Critical History', Thames and Hudson, 1992, p. 323.

17 As Robin Evans suggests Le Corbusier used oppositions wishing to be portrayed as 'a potential unifier of opposites'. Robin Evans, 'The Projective Cast, Architecture and Its Three Geometries', The MIT Press, 1995, p. 276.

18 Le Corbusier, 'Towards a New Architecture',

19 Alan Colquhoun, Ibid., p. 31-50.

20 Alan Colquhoun, 'Modernity and the Classical Tradition', The MIT Press, 1989, p. 169.

21 Ibid., p. 169.

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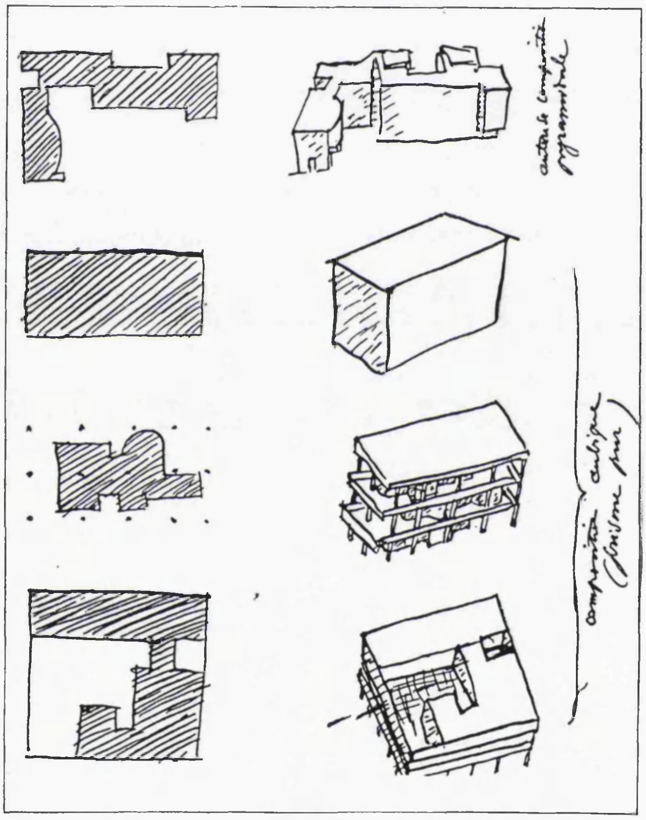


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Colquhoun interprets the dialectic between form and function as a dialectic between order and improvisation, symmetry and asymmetry, classical regularity of volume and grid and customary irregularity of surface and plan. *Thus, there is a direct line that connects regularity with form and irregularity with function. There is also a direct line that connects the former with a 'primary experience' deprived of meaning and the latter with a cultural experience endowed with functional expression.* In Colquhoun's words: 'It is necessary to express both the functional and the Platonic systems, since to express only the second would deny the functional reality and assert a form that was empty of meaning'[22].

Meaning is carried not through the ways the architectural elements come together to define systems of properties but through the capacity of these elements to carry social purposes. From the opposition between form and figure to the opposition between form and function Colquhoun moves along the same border that separates *meaningless form* from *meaningful figure* and *meaningful function.*

Stanislauss Von Moos observes the same duality between a simple exterior conceived as a single box and a complicated interior patterned by picturesque informality in Le Corbusier's architecture. Similarly to Colquhoun, Von Moos suggests that Le Corbusier combines conflicting tendencies towards 'Platonic' form and the pragmatics of reason[23].

The idea that Le Corbusier offered a resolution between form and function is supported also by Frampton[24]. Le Corbusier's four compositions, combining a public front of classical form with a complex interior of comfort and informality are the clearest demonstration of the resolved conflict, (illustration 1.3). Le Corbusier, Frampton says, combined '... the imperative to satisfy functional requirements through empirical form and ... the impulse to use abstract elements to affect the senses and nourish the intellect'[25].

The dialectic between form and function, regularity and irregularity, order and disorder is interpreted as a dialectic between 'ideal order', (Platonic-abstract form), and 'pragmatic order', (functional-empirical form)[26]. Ideal order refers to a 'primary experience' that is fixed a - priori. Pragmatical order refers to an empirical experience emerging from utility and the phenomena of every day life.

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22 ibid., p. 31.

23 Stanislauss von Moos, Ibid., p. 80.

24 Kenneth Frampton, Ibid., p. 158.

25 Ibid., p. 108.

26 Ibid., p. 108.

It is beyond the scope of this section and this research in general to undertake an extensive examination along the contrasts abstract-real, ideal-empirical. However, reference to these contrasts will be made in the following section which discusses form and geometry within a broader theoretical framework.

The paradox of the division between abstract and empirical form, as put forward by these authors, seems to lie in an identification with a division between regularity and irregularity. Regularity belongs to abstract form. Irregularity belongs to the pragmatics of function. *However, if order and symmetry are abstract properties of the architectural object, so are disorder and asymmetry.*

Thus, the dichotomy these authors point at seems to be about two faces of the same reality. To see these notions as divided suits a belief that binds order and form to emptiness and disorder and function to meaning. It might also derive from a belief that considers order as an absolute concept capable of describing only the overall form of the building and not its principles of articulation.

Von Moos extends the notion of function from the total set of activities in a house to the activity itself, to the notion of dwelling[27]. The connection between form and function is carried through the notion of the 'type', a configuration that ties an overall formal concept, like the Platonic box, to an activity. Le Corbusier developed four such types: the dwelling module, (box), the museum, (spiral), the stadium, (bowl) and the assembly hall, (triangle)[28]. These types later accommodated a number of different purposes. Thus, von Moos concludes, Le Corbusier's forms develop independently of specific functions.

The example of the church demonstrates Le Corbusier's denial of the idea of a link between an overall formal concept and an activity. Le Corbusier never addresses the notion of the 'sacred' in the way classicism did.

'Thus, Ronchamp belongs, typologically, to the same building category as the small Assembly Hall of the Millowner's Association in Ahmedabad; it is not a chapel by virtue of its form, but by its intensive sculptural articulation - and the strong medieval overtones of the twilight interior'[29].

What follows from these writings is that the dichotomy between form and figure, form and function, regular and irregular form is based on an assumption that form is associated only with the external appearance of buildings, with an overall geometrical principle described such as the box, the spiral, the bowl or the triangle.

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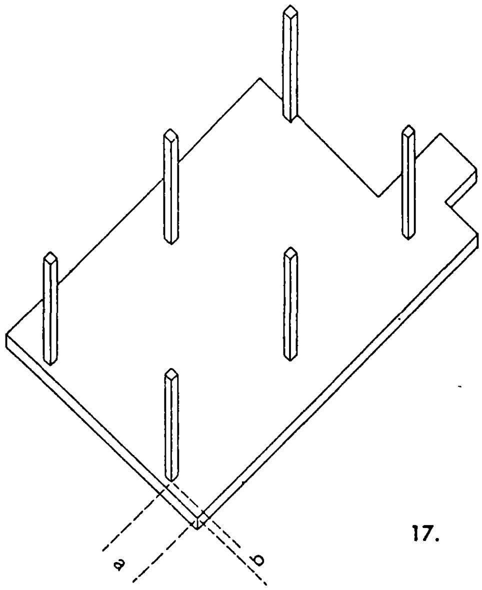
27 Stanislauss von Moos, ibid., p.p. 101-104.

28 ibid., p. 102.

29 Ibid., p. 103.

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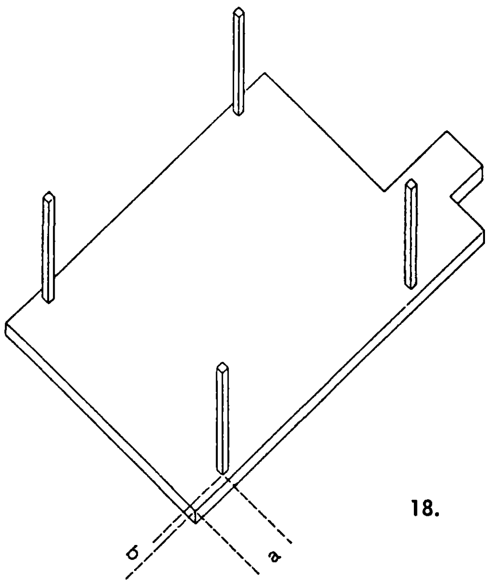


18.

The abstraction characterising this simple geometrical concept is what makes its functional and cultural signification vague and unstable. This seems to explain why Ronchamp's irregular shape lacking a simple geometrical description of the above kind, can express 'the sacred' not by virtue of its form, but by virtue of its 'intensive sculptural articulation'. It also seems to explain why cultural meaning for these authors is carried by figures and irregular arrangements accommodating function. *Thus, form is meaningless because is seen as lacking a degree of articulation necessary to carry meaning through its own mode of constitution.*

- **Form and the self referential sign**

Peter Eisenman opposes the view that meaning in Le Corbusier's architecture derives from social signification. On the contrary, it lies on its ability to refer to itself[30]. In the Do-mino structure the a/b relationship between the distances of the columns from the edges of the slab intensifies the A/B relationship between its long and short sides, (illustration 1.4). This shows an 'intentionality' that choosing a particular proportional relation from all possible ones expresses its concern for the internal operations that give rise to the architectural object. Thus, the Do-mino becomes a 'self-referential sign', an existence of 'an architecture about architecture'.

For Eisenman this sign no longer concerns itself with how it becomes intelligible. It is concerned only with its own 'objecthood'. The old conception of the facade, as something that shaped and directed the experience of a viewer is something that speaks outside itself. The horizontal slab of the Do-mino is not an 'extra-referential' sign. It does not structure the experience of an observer. It expresses only 'intentionality' and its horizontal extension, an idea of its own physical condition.

Hjelsmslev's distinction between 'expression form' and 'expression substance' can explain Eisenman's notion of the self-referential sign[31]. Hjelsmslev proposed that the plane of expression, i.e. the formal properties of a system, can be divided into the plane of form and the plane of substance. The former refers to the formal properties themselves. The latter refers to what these properties signify: the repertory of possible articulations. It is this second plane that Eisenman's self-referential sign identifies with.

Eisenman is distinguished from the theories of social signification pointing at the necessity to look at architecture's own laws. This, he argues, is the only way architecture is separated as an 'intentional act' from building, from the idea that a wall is simply 'sheltering, supporting and enclosing'[32]. Prior to its cultural or functional considerations architecture is about formal articulation.

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30 Peter Eisenman, 'La Maison Dom-ino', in the book 'In the Footsteps of Le Corbusier', Rizzoli International Publications INC., 1991, p.p. 21-35.

31 Luis Hjelsmslev, Prolegomena to the Theory of Language', Trans. by Whitefield, Baltimore Warerly Press, 1953.

32 Peter Eisenman, Ibid., p. 34.

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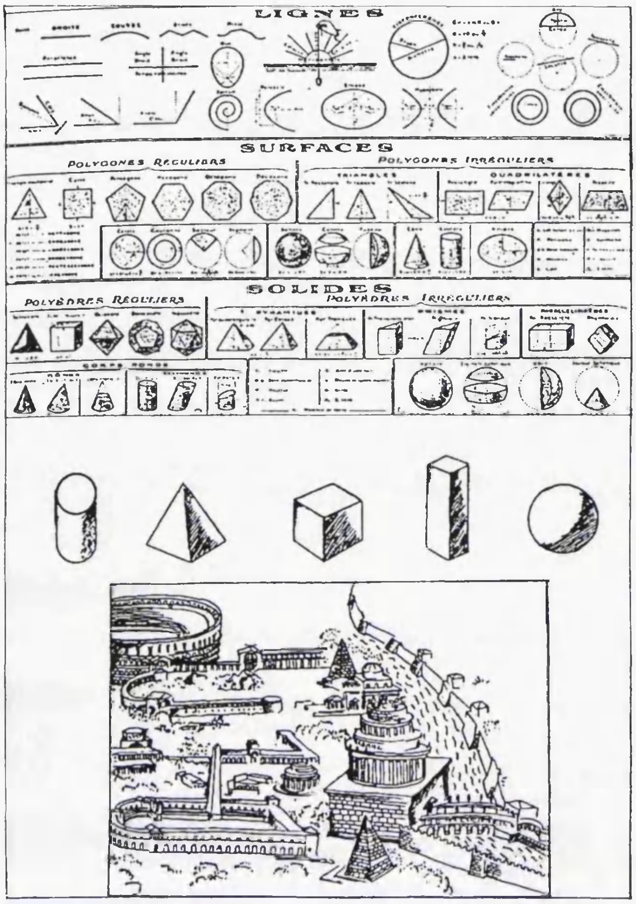
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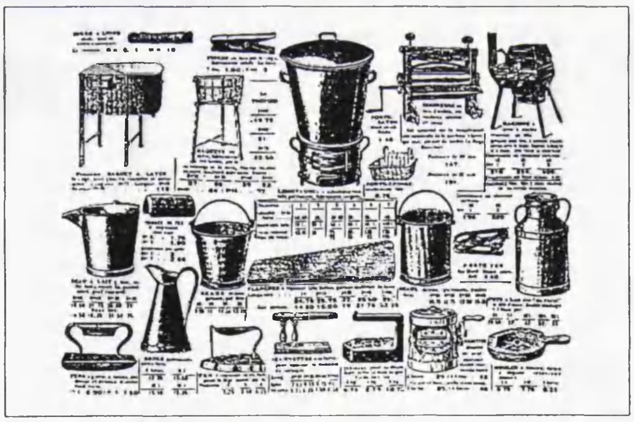

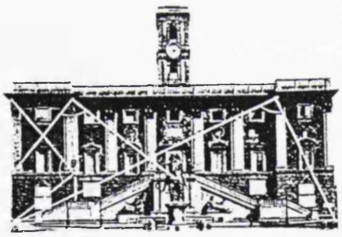

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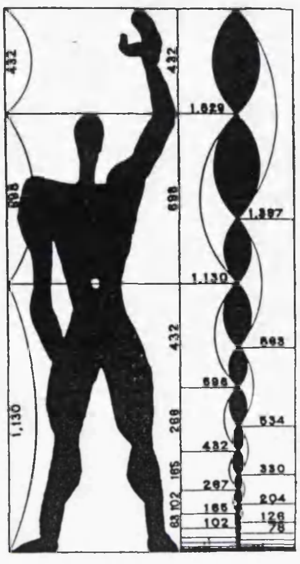
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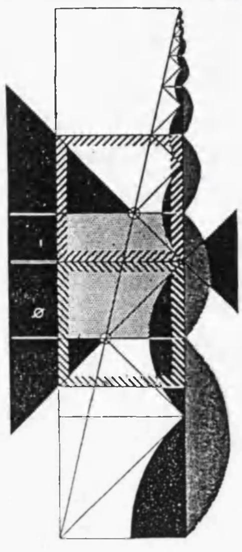

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However, this articulation signifies a combinatorial realm rather than carrying its own meaning. In the need to strip architecture from extra-referential capacity, Eisenman denies its capacity to be intelligible. Thus, he seems to approximate the authors discussed before that consider architectural form as meaningless.

- **THEMES FOCUSING ON PROPORTIONS AND GEOMETRY**

- **Proportional and Platonic form**

Le Corbusier's extensive use of geometry and harmonious ratios has often directed scholars to examine their embodiment into his architecture[33]. The geometrical control characterising Botta's buildings reveals a similar preoccupation with geometry that has hardly escaped criticism[34]. Thus, contrary to theories that examine Le Corbusier's and Botta's' buildings as referential systems, a number of theories exist that examine them as mathematical and geometrical systems. These fall into three categories:

- Theories of proportions attributing a numerical order to buildings.
- Theories of Platonic form examining the overall geometrical shape of buildings.
- Theories of proportions and Platonic form[35].

- **Theories of proportions.**

Rudolf Wittkower focusing on Le Corbusier's Modulor[36] and its role in a historical context[37] proposes that the Modulor is a poetic reinterpretation of 'man's intuitive urge' to seek order in natural and artificial

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33 The clearest expression of Le Corbusier's interest in geometry is found in his drawing of the basic geometric solids published in 'Vers Une Architecture', (illustration 1.5). In the same book an illustration of Michelangelo's Capitol with superimposed regulating lines forms an expression of his interest in mathematics and proportional systems. The 'Modulor', a measuring tool based on the human body, expresses the culmination of this interest.

34 The geometrical precision characterising Botta's buildings extends from the largest scale of the building as a whole to the smallest detail of its formal and constructional articulation.

35 A theorist might examine both geometrical and mathematical concepts. He might examine them separately from each other or in conjunction with each other. Nevertheless, his theoretical proposition might be that architectural form is determined either by the one or by the either or by both. It is this proposition or assumption that forms the criterion by which the following approaches are classified.

36 The Modulor was an anthropometric tool intended to combine mathematical harmony, nature and man made structures, as well as to provide a means for industrial standardisation. Starting like Vitruvious with the human body Le Corbusier divided it into two ratios according to the golden section, (illustration 1.6). These ratios are also the bases for two series of numbers, known as the Fibonacci series, in which each unit is equal to the sum of the two preceding ones. Thus, two neighbouring values in this series have a ratio that approximates the ratio

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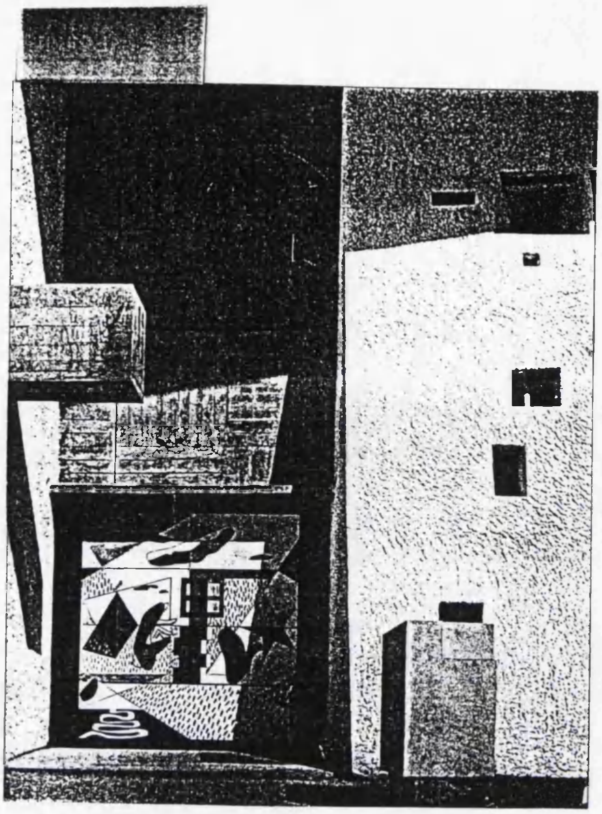

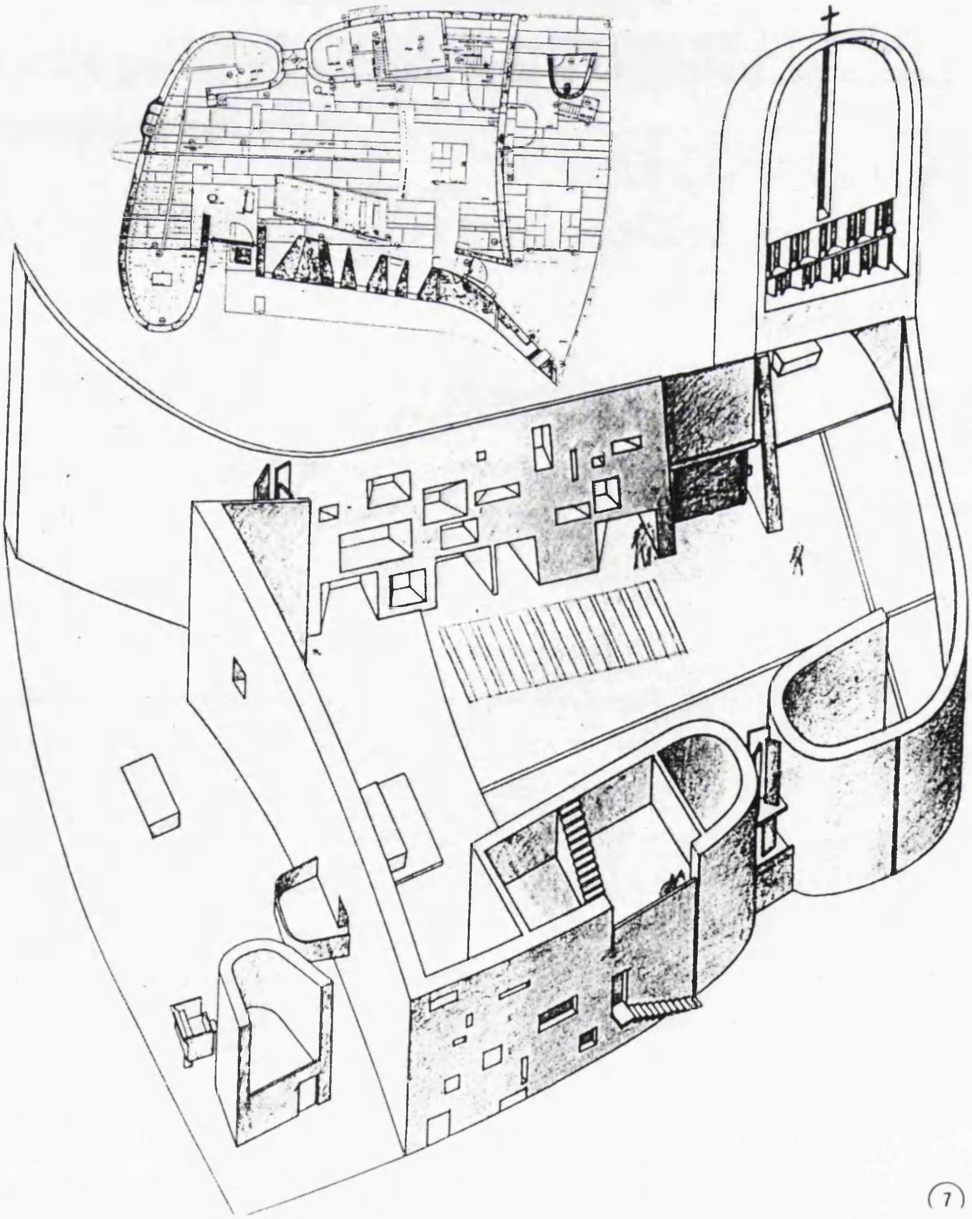

systems. As such, it shows Le Corbusier's belief in its 'metaphysical power' to express 'a divine order of things'. It also shows a belief in the connection between the laws of harmony and aesthetic satisfaction. Regardless of the truth or fallacy of this connection, Wittkower says, these laws enriched the world 'by the most beautiful buildings'[38].

Similarly to Eisenman, Wittkower sees architecture as a poetic activity established by the creative powers of a mind that controls a body of relationships. Unlike Eisenman, though, he suggests that these relationships are fundamental in structuring intelligibility. The proposition seems to be that *it is architecture's own mode of operation that is capable of carrying and structuring intelligibility.* Thus, with Wittkower the discussion of architecture moves from representation to constitution.

Nevertheless, the notion of a building as a product of a unified system of proportions does not explain buildings that are not products of such systems. Besides, Wittkower's conviction that proportions give design aesthetic value does not explain where the aesthetic qualities of these buildings lie. *His belief on a mathematical order as a prerequisite for the aesthetic and intelligibility supports only one type of order.*

Wittkower seems to be more interested in defending proportions[39] and less in describing how they affect intelligibility. Hence, he neither looks at how the Modulor is embedded in any of Le Corbusier's buildings, nor he demonstrates what proportions mean if one wants to understand these buildings.

For Robin Evans proportional relations as formulated by the traditional practice and by the Modulor are inadequate in describing complex shapes[40]. In the chapel of Ronchamp, Evans proposes, the Modulor is evident only in the paving, the altar tables and the iconography of the door, (illustration 1.7). Elsewhere it is buried behind the inclining walls and the twisting roof of the church that seem to reject both an

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of the golden section. Finally, each value in each series has a relation of 1/2 to the opposite value in the other series.

37 Wittkower places the Modulor within the architectural tradition that based on Pythagorean and Plato's theory attributed numerical and geometrical order in nature and in man-made structures. For Wittkower Le Corbusier was the only architect that since the demise of this tradition at the eighteenth century and after its revival by industrial standardisation believed that architecture is proportion. Rudolf Wittkower, 'Le Corbusier's Modulor', in the book 'In the Footsteps of Le Corbusier', Rizzoli International Publications, 1989, p.11-19.

38 Ibid., p. 13.

39 Wittkower attempts to restore proportions using their historical connection with cosmological symbolism and the emphasis philosophical thought and architectural practice has devoted to them. Similarly to Jenks who is convinced about the creative power of Le Corbusier by the persistent interest theories and architects have shown in his architectural principles, Wittkower is convinced about the aesthetic power of proportion by its persistent application since the Pythagorean discovery and up to the eighteenth century.

40 Robin Evans, Ibid., p.p. 273-320.

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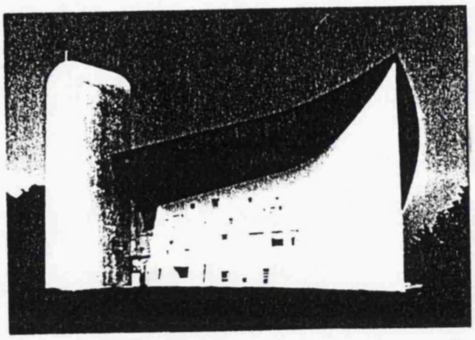

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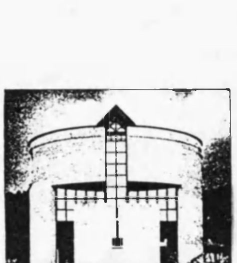

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overall clear form and an orthogonal system, (illustration 1.8). On the other hand, in Le Corbusier's villas proportions are 'pulled up' to the very threshold of perception so that they can be perceived by a naked eye[41].

Rudolf Arnheim is also interested in how proportions are visually grasped. The weakness of the Modulor for Arnheim is that only relations amongst contiguous values can be captured visually[42]. This is because only these values have a simple relation to each other[43]. Thus, *it fails to explain those visual principles that relate distant parts irrespectively of their size.* As such, its contribution to intelligibility is questionable.

The Modulor might express an artistic yearning for an objective description and justification of design choices. However, an account of design based merely on proportions abstracts the process of understanding substituting a visual for a numerical order of things. Arnheim suggests that a pattern is mainly understood by its 'geometrical simplicity' in which every part has a visual relation to every other and to a coherent whole. The fitting of the human body in a circle by Vitruvius, is an example of such pattern, (illustration 1.9). Thus, with Arnheim and Evans the discussion of architectural form and intelligibility moves *from abstract mathematical to visual geometrical pattern.*

- **Theories of Platonic form**

The notion of a visual order based on geometrical simplicity preoccupies a number of other theorist who approach a building in terms of its capacity to register as a simple geometrical shape.

Alberto Sartoris discussing Botta's cylindrical house, (illustration 1.10), focuses on its circular shape and on its ability to demonstrate the union between space and nature[44]. Similarly to Wittkower, Sartoris brings a number of historical examples to illustrate the 'symbolism' and the 'magic' of this shape. In

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41 ibid., p. 292.

42 For Arnheim the Modulor is an attempt to compromise two different proportional systems: the golden section with the Fibonacci series. The former, defines the whole as something that is subdivided to a number of proportional units. Vitruvious' analysis of the human body is an example of this system in which 'the head is 1/8 of the total height; the face and hand are 1/10 each; the foot is 1/6; the cubit 1/4 and so on'. The latter defines all parts of a pattern as multiples of the same unit. The Fibonacci series is a more sophisticated version of the second system in which values are not multiples of the same unit but increase gradually according to an arithmetic progression. <u>Rudolf Arnheim, 'Towards a Psychology of Art'</u>, University of California Press, 1966, p. 112.

43 For example whereas the values 33, 53 and 86 have a simple relation, (33+53=86), the multiples of 33 and 53 have no relationship to 86. Besides, although in each of the two series each value has a relationship of 1/2 to its opposite number at the other 'the relations between members of the two series is far from simple'.

44 <u>Alberto Sartoris, 'Mario Botta La Casa Rotonda'</u>, Edizioni L'Ebra Voglio, 1982, p. 84-85.

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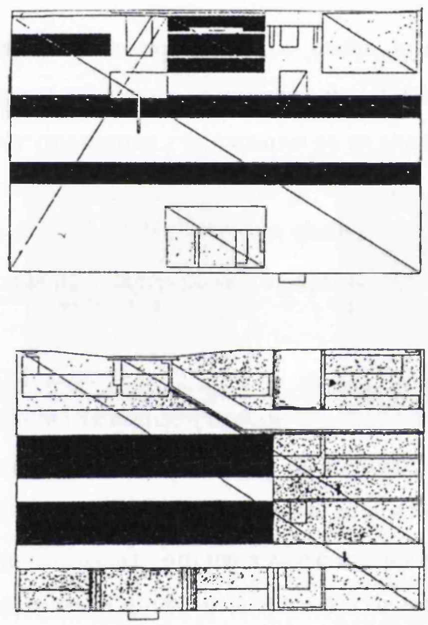

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Botta this symbolism is combined 'with the modern cult of a life able to flow with a rhythm both serene and humane'.

In spite of a few references to the ways the cylinder is vertically and transversally cut, and on Palladian regulating lines, Sartoris' description of geometry is limited to the circle. The definition of Botta's volumes as simple geometric solids is undeniable. However, Sartoris isolates the circle from a body of relationships that seem embedded in it, like the ways it is perforated to incorporate outside spaces or voids or the ways it is subdivided to accommodate individual spaces. Focusing on the visual element of the circle rather than on relations, he deprives architecture and geometry of a structure[45].

- **Proportions and Platonic solids**

It becomes evident that diverse theories emphasise a single geometrical concept. From the theories of social signification to the theories of mathematics and geometry, architectural form is identified with the overall shape of a building. Certain scholars, though, like Von Moos place an emphasis on both Platonic shape and proportions.

For Von Moos the significance of the Modulor lies in the establishment of a system that 'visualises a world too complex to be seen and understood without it'[46]. Nevertheless, this system can often result in a 'visual disorder'. 'For although the Modulor is capable of organising parts, it can never control the composition of an architectural whole'. However, in his description of Villa Stein, (illustration 1.11) Von Moos provides a contradictory statement:

'The supports divide the plan and the elevations into a basic rhythm 2:1:2:1:2. Although this is not clearly expressed on the facade-as usual, the "pilotis" stand behind the screens of the outer surfaces-it determines their visual organisation'[47].

Proportions enable the understanding of a visual system, but they can result in visual disorder. They determine the visual organisation of a facade but they remain hidden behind its surface. Besides, they control the organisation of the parts but not the composition of the whole. It seems that Von Moos distinguishes between hidden properties operating at a local level and properties that are evident controlling the overall level.

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45 Like Wittkower, Sartoris is more interested in the symbolic mysticism of shapes than in the geometrical constitution of buildings. So, he neither describes this constitution nor he examines the cosmological unity or the 'serene' and 'humane' rhythms of modern life he claims it represents. It seems that in the need to explain the void left by the absence of a connection between the circle and religious and scientific ideas Sartoris replaces them with the 'serene' and 'humane' rhythms of everyday living.

46 Stanislauss Moos, Ibid., p. 313.

47 Ibid., p. 79.

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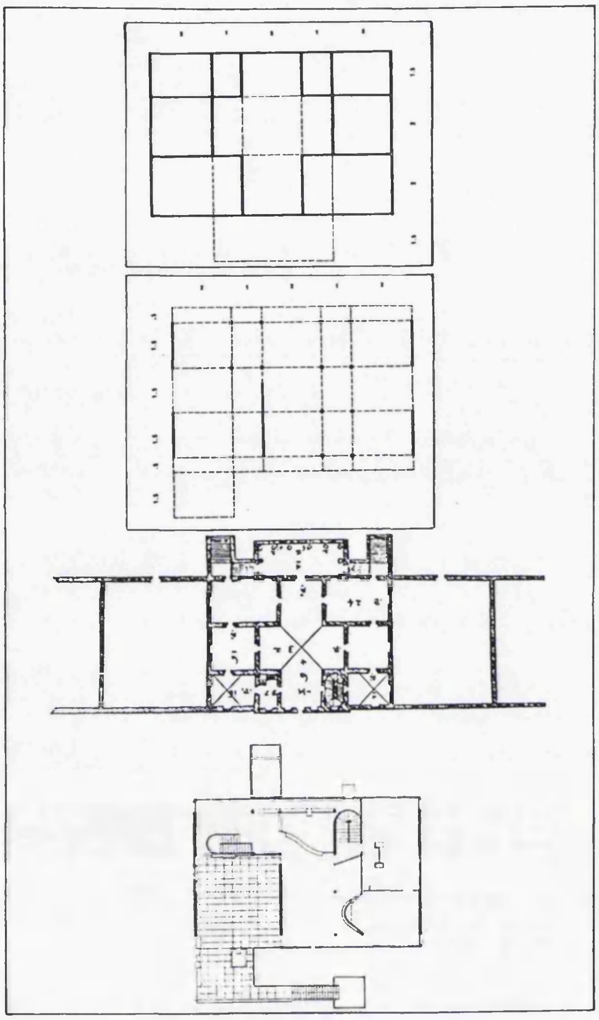

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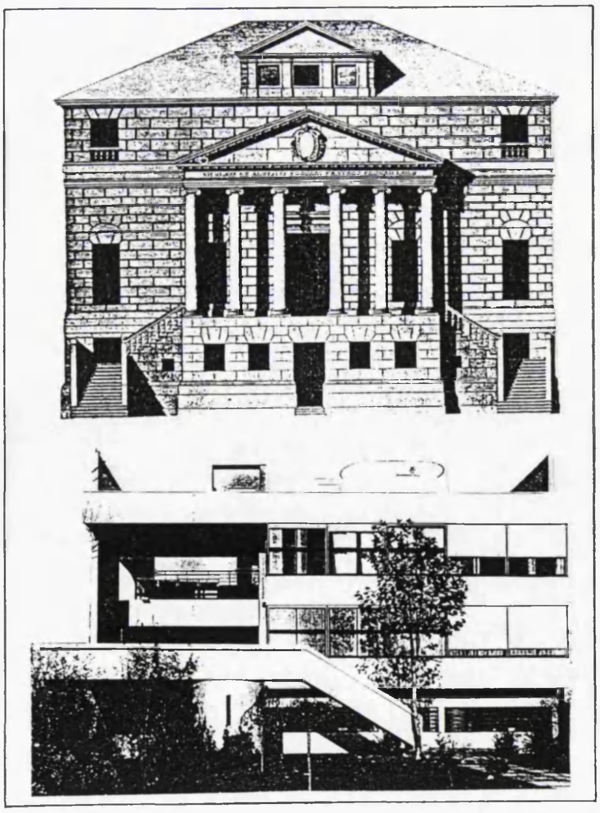

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He seems to believe that the ways this visual system is conceived by the designer is different from the ways is perceived in real experience. He seems also to imply that perception can rely on the mathematical, invisible and local properties but conception relies on the non mathematical, visible and global properties. It seems that this visible global system refers to the overall form of the building, and to its conception as a simple geometrical shape.

Inspite of his contradictions, though, Von Moos raises the same question as Arnheim and Evans: Are proportions and geometry compositional devices controlling the visual organisation of the whole? With Colin Rowe the analysis of proportions and geometry in the context of the visual experience is carried further.

- **Geometrical and physical form**

Rowe compares the proportional and geometrical principles of the structural grid of Villa Stein with those of Palladio's Villa Malcontenta[48]. He examines how proportions affect the symmetrical spacing of the geometrical bays constructing 'focus' on one hand and a tension between 'focus' and 'dispersion' on the other, (illustration 1.12).

'In other words by the use of a cantilevered half unit Le Corbusier obtains a compression of his central bay and thereby transfers interest elsewhere; while Palladio secures a dominance for his central division with a progression towards his portico which absolutely focuses attention in these two areas. The one scheme is, therefore, potentially dispersed and possibly equalitarian and the other is concentric and certainly hierarchical;...'[49].

Rowe's analysis moves from the grid to the space, the facades and the volume. He observes a contrast between the symmetrical organisation of these systems in Malcontenta and their asymmetrical organisation in Villa Stein, (illustration 1.13). He also compares these systems with the structural grids. Whereas in Palladio the symmetry of the grid is repeated at the arrangement of the rooms, in Le Corbusier there is only a 'Z-shaped balance' resulting from the large excavation at the left side of the building.

In the facade Le Corbusier allows the regulating lines to be more obvious. On the other hand, Palladio's facade conceals the geometrical co-ordination of parts so evident at his plan. In the section the vertical modelling of Malcontenta enables the cruciform hall to reassert the plan's symmetrical ordering. In Villa Stein the horizontal extension of space contained in between the slabs accentuates the plan's disperse character.

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48 Colin Rowe, Ibid., p. p. 2-17.

49 ibid., p. 4.

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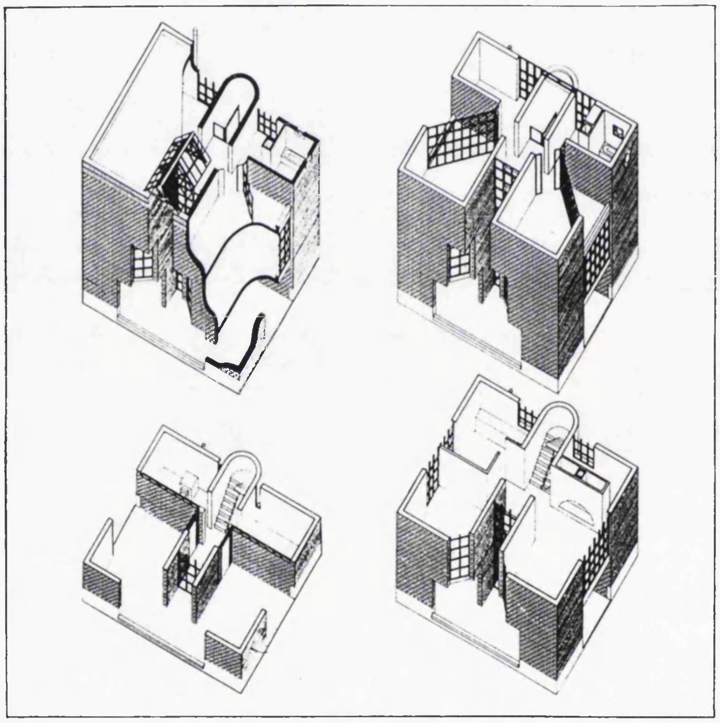

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As Rowe observes :

'... both houses seem to be apprehensible from without; but from within, in the cruciform hall of Malcontenta, there is a clue to the whole building; while, at Garches, it is never possible to stand at any point and receive a total impression'[50].

Rowe looks at how proportions are embedded into a geometrical system sustaining properties like symmetry and repetition, focus and dispersion. He also looks at how the proportional-geometrical, and the corporeal-spatial systems, interact. There are moments in which symmetry is a not a mere property of the structural skeleton. It is a property of the volume and as such is visually asserted. There are also moments in which symmetry is evident only at the level of this skeleton which lacks that kind of flesh that gives the plan, facade, volume and space physical presence. *Thus, Rowe focuses on the ways proportions and geometry are manifested into a world of physical presence becoming visually identifiable.*

Once this is made clear the 'diffusion' of the grid into the volumes of the interior in Malcontenta as opposed to the resistance of this diffusion in Stein becomes also clear. The walls at Malcontenta follow the lines and the logic of the structural grid. Those at Stein do not. Thus, the identification of a structural system and a wall system, that in the case of Palladio coincide, whereas in the case of Le Corbusier they do not, becomes the clearest and most useful contribution to the description of Le Corbusier's work as well as to its relation to Palladio.

The relation of corporeality to a footprint of a geometrical grid and its free arrangement in relation to it in Le Corbusier's Villa Stein is also stressed by William Mitchell.

'The footprint is punctuated by a grid of columns rather than subdivided by a grid of wall zones. Plan layout problems are solved by freely instantiating[51], translating and rotating wall segments, rather than by concatenating grid cells'[52].

In his account of Botta's architecture Pierluigi Nicolin also focuses on the relationship between the geometrical and the physical aspects of a building[53]. For Nicolin a house by Botta is a primary volume broken along the south-north axis with a staircase at the south end of the axis and a large opening at its

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50 ibid., p. 12.

51 The notion of 'instantiating' comes from Mitchell's notion of 'instances' meaning physical elements 'located in a particular place, in a particular time'. Thus, instantiating means incorporating types of elements into a physical object, William Mitchell, Ibid., p. 86.

52 William Mitchell, The Logic of Architecture, Design, Computation and Cognition', The MIT Press, 1990, p. 232.

53 Pierluigi Nicolin, 'Mario Botta, Architecture 1960-1985', Electa 1985, p. 270.

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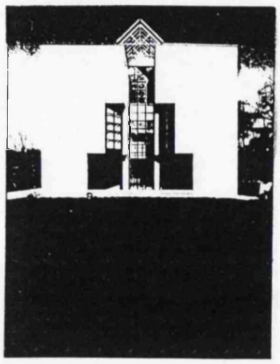

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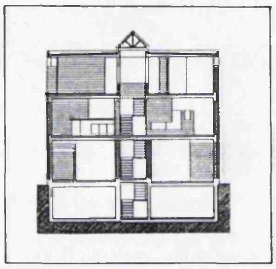

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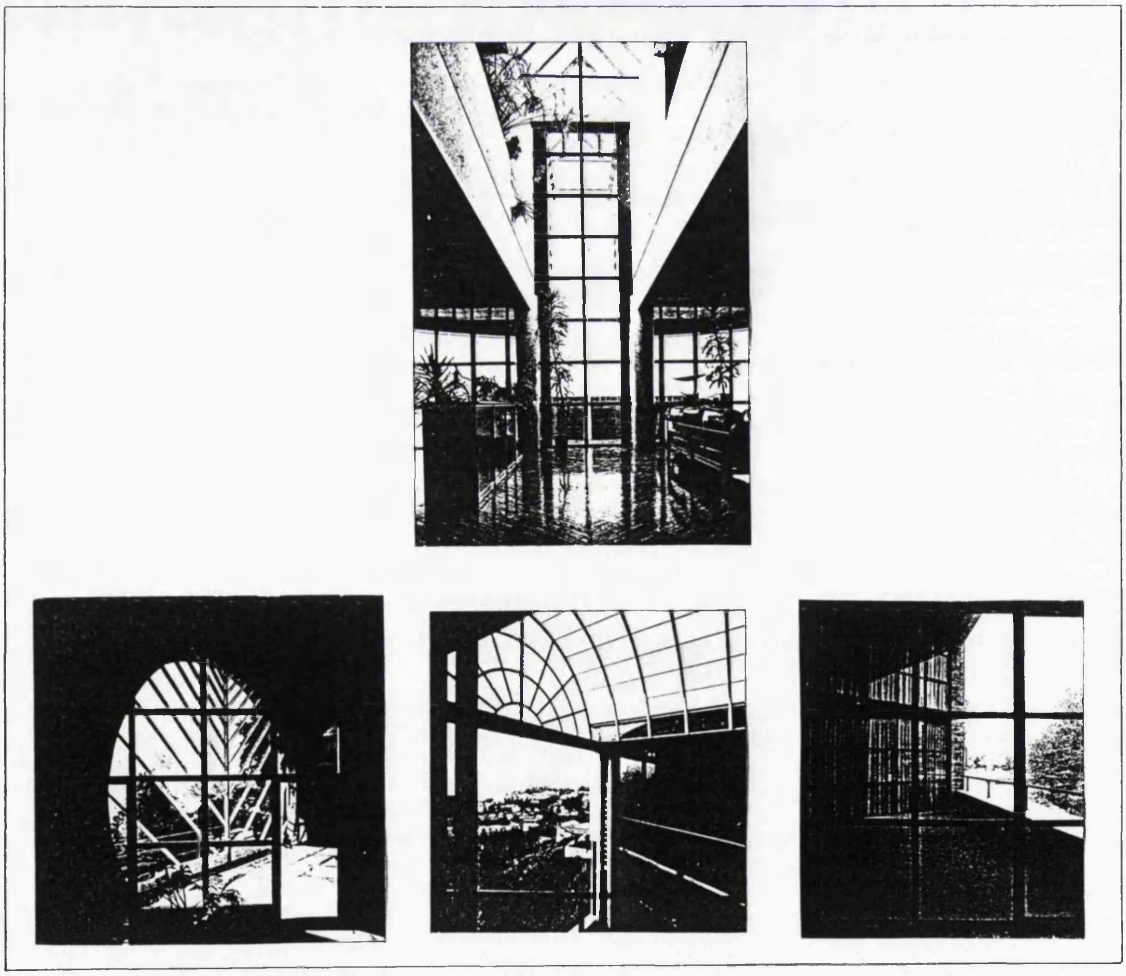

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north end, (illustration 1.14, p. 37). Thus, the geometrical symmetry of the volume is expressed by the physical articulation of the plan.

A house by Mario Botta is also excavated along the north-south axis replacing the traditional windows with large openings that enter into a figure-ground relation with the plane of the facade, (illustration 1.15). Thus, the volumetric excavation is expressed in the relationship of solids and voids in the facade. A common geometric structure underlies plans and facades making itself evident at the physical level.

Mirco Zardini also suggests that in Botta's houses volume, facade and space are integrated through the geometrical sculpturing of a simple solid[54]. Excavation pierces the front and the roof of the house allowing the light to penetrate in section, (illustration 1.16). It is the section that generates the interior space with its full length slots carrying the light inside the building. The lack of clear separations between the spaces allows one 'to perceive the fundamental unity of the interior volume'. A kind of interior transparency is created through a series of loggias that project inwards. These loggias are unified with the internal voids, the skylight and the staircase into a single system.

Similarly to Rowe who observes that the cruciform hall of Malcontenta enables one to understand the building as a whole, Zardini suggests that the interior of Botta's house reveals its unity. Thus, he is concerned with the ways the geometrical principles of the house become evident to a viewer standing inside the house.

He is also interested in how one grasps Botta's houses as one approaches, enters and moves inside them. The volume creates a dialogue with selected landscape elements that is gradually experienced as one walks along the pathways leading to the building. These pathways continue in the interior establishing a new dialogue through selected views framed by the various openings, (illustration 1.17).

For the authors examined in this section properties of form identify with geometrical relations governing architectural elements or systems of elements like spaces, structural supports, horizontal and vertical planes, solids and voids, facades, sections, and plans. What is fundamental in their examination is the ways the geometrical properties are manifested through these physical systems. Thus, with these authors the discussion of architectural form moves *from absolute and elementary concepts like proportions and platonic form to relational and more complicated ones. It also moves from an abstract realm of a-priori significance to the physical realm of architectural space.*

The assumption these authors make is that it is to the observer that geometry communicates its organisation. This communication occurs not in an abstract space of proportional and geometrical combinations but in a specific architectural space seen, transversed, used and interpreted.

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54 Mirco Zardini, 'Mario Botta, architecture 1960-1985', Electa 1985 p. 47-93.

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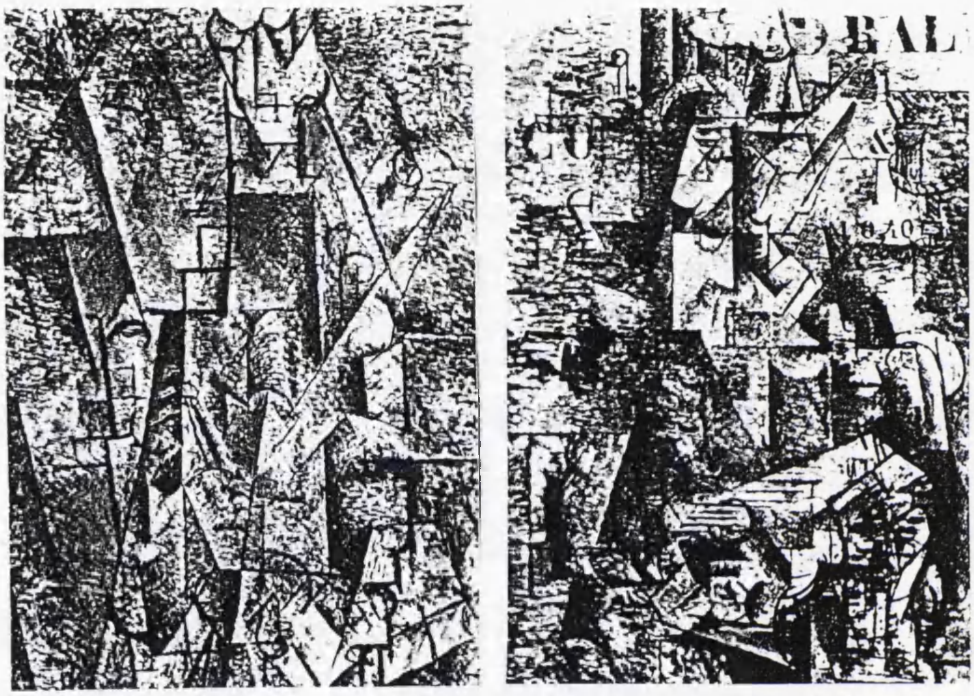


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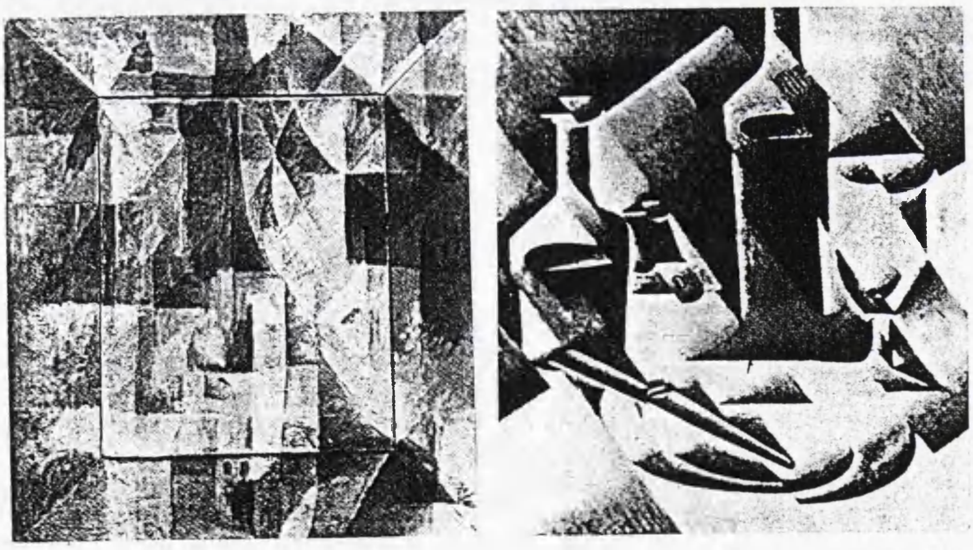

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However, the space the observer occupies in these discussions is ambiguous. In their descriptions the viewer is suspended in between a space of geometrical relations, the space of Stein's proportional rhythms, or a space of flat projection, a space represented on plans and elevations, or the conventional space filled by his bodily presence, in front of Stein's front surface, or under the skylight covering the vertical slot of Botta's houses.

What can be argued from the above writings is that one can occupy any of these spaces and grasp Palladio's or Botta's houses at once[55], To comprehend Stein, though, the observer can hover from one space to the other and grasp with easiness only the immaterial space of the grid, a space that is 'acceptable to the intellect alone'. As Rowe suggests, the observer crossing the other spaces in Villa Stein is left 'sensually perplexed'. Nevertheless, Rowe leaves also his reader perplexed as he tries to follow his route through the geometrical abstractions, the concreteness of the drawings and the sensual complexities of Stein's interior space.

Thus, there is no clear idea about the ways geometry, drawing and architectural space are distinguished from each other. There is no clear idea about how geometry structures intelligibility in each of them either. The following sections attempt to explore these questions further.

- **Actual and shallow form**

The ambiguity of the space an observer occupies in these writings might result from a belief that the boundaries between geometry, drawing and actual space are blurred rather than sharp. It might also result from a belief that they all play their part in the attainment of intelligibility. Alternatively, it could be seen as stemming from an assumption that drawing is analogous to architectural space. Finally, it might result from the lack of an analytical framework that distinguishes geometry from drawing and actual space and examines their relations.

A comparison of the space expressed in Cubist paintings and the space expressed by the vertical and horizontal layering of the facade of Villa Stein carried out by Rowe and Slutzky[56] provides a useful basis on which to discuss the above possibilities.

In a discussion of analytical Cubism the authors distinguish between paintings that clearly distinguish between figure and ground and those that do not. The former represent surfaces in the third dimension, expressing a *'deep'* space, (illustration 1.18). The latter flatten this dimension through a series of

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55 As it was mentioned above this is because in Palladio the focused structure of the grid, the symmetrical structure of the plan and the centrally placed cruciform hall give a clue to the whole building. In Botta it seems that the same properties allow one to comprehend the geometry, the plan, facades and space.

56 Colin Rowe, Robert Slutzky, 'Transparency Phenomenal an Literal', in the book 'The Mathematics of the Ideal Villa and Other Essays', The MIT Press, 1984, p.p. 157-183.

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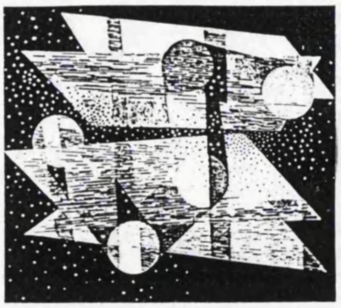

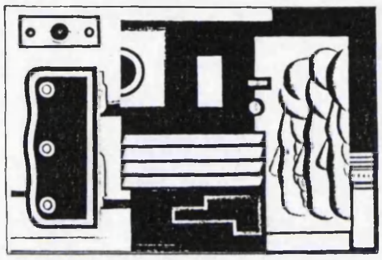

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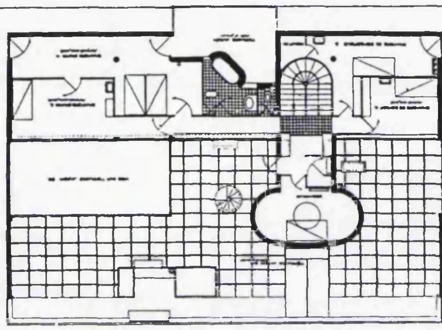

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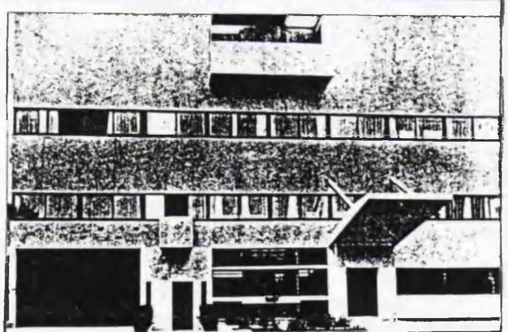

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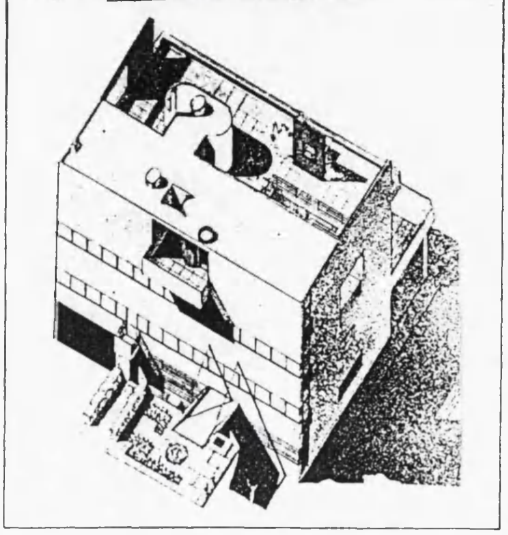

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fluctuating planes. These planes take simultaneous locations in front and behind each other creating a *'shallow, abstracted'* space, (illustration 1.19, p. 39). The former is concerned with the *depiction of space*, the latter with the depiction of *form* and *surface pattern*. The former deals with volume, materials and light generating *'literal transparency'*. The latter is concerned with the absence of volume and the two dimensional organisation of planes creating *'phenomenal transparency'*.

Le Corbusier's preference for frontal view point, the authors suggest, refers to the Cubists picture plane. Besides, the vertical stratification of existing and 'imaginary' planes[57] refers to the interpenetrating shapes in Leger's painting *'Three Faces'*, (illustration 1.20). A viewer looking at the facade of Villa Stein *infers* a layering of vertical planes that implies a layered organisation of the interior space. A view of the house from the top exhibits also the same principle of overlapping horizontal surfaces, (illustration 1.21). These layers form an extension of phenomenal transparency from the flat surface of Cubist paintings to three dimensional space.

'Recognising the physical plane, glass and concrete and this imaginary, (though scarcely less real) plane that lies behind, we become aware that here a transparency is effected not through the agency of a window but rather through our being conscious of primary concepts which "interpenetrate without optical destruction from each other" [58].

From a first point of view the proposition that the layered space of Villa Stein is 'shallow' seems paradoxical. Regardless of whether Leger expresses a 'shallow' or 'deep' space, his fluctuating planes belong to the *flat surface* of the painting[59]. On the other hand, both the existing and 'imaginary' layers of Villa Stein occupy *actual three dimensional space.*

The assumption that these two spaces fuse into the same one can be expressed by the plates the authors use to demonstrate their points, (illustrations 1.2 2, 1.23). These plates show the two fronts of Villa Stein and an axonometric drawing. In the former the observer *is anchored on the ground plane.* In the latter *he floats above the building.* Thus, Rowe's and Slutzsky's observer dwells in both spaces, the space of gravity and a space that defies it, i.e. the space of drawing.

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57 One of these imaginary planes, Rowe and Slutzky identify, is the one suggested by the recessed surface of the ground floor, the free standing walls terminating the terrace at the roof and the glazed slots at the sides of the house.

58 Ibid., p. 168.

59 As the authors themselves suggest, the ambiguities in Cubism constantly remind the viewer of an extended space as well as of the painted surface. ibid., p. 163.

A drawing like the one used by the authors offers simultaneous views of the facade and the roof of the building that are not possible in actual space. However, the authors suggest that in Villa Stein a frontal station point of view can capture relations like those expressed in a drawing.

It is not suggested that Rowe and Slutzky ignore the fact that drawings and buildings are not similar or that the simultaneous occupation of multiple view points by an observer is something that no real condition can ever assist. On the contrary, it seems that this is what they try to show using the example of painting, the only situation in which such simultaneity exists. The clearest modern example of an ambiguous position of the observer is found in the pictorial space of Cubist painting[60]. Cubists attempted to create a total image as a by-product of a perceptual synthesising procedure. Its depiction was based on a composition of partial views that are simultaneously seen from different view points.

Thus, what the authors seem to imply is that similarly to Cubist paintings that allow an occupation of multiple points of view, the facade of Villa Stein allows *a perceptual detachment of the viewer from the space he occupies to the space that lies ahead behind the planes of the facade.* Besides, similarly to the fluctuating planes of Leger which make one aware of overlaid patterns on a flat surface, *the perceptual fluctuation of the observer back, front and above his station point make him also aware of simultaneous patterns. This simultaneity squashes them into a perceptual shallow datum.*

Therefore, if the space of cubist painting is a space of cognition, the space the facade of Stein depicts is also a space of cognition. As the authors suggest, one does not see 'actual shallowness' but is aware of an 'implied shallowness'.

Thus, an observer seeing the front of Villa Stein is aware of a shallow space analogous to the pictorial plane of flat projection. In this plane, facades and interior are dislocated from their positions in space, shrank into a perceptual flatness and simultaneously seen. It is like seeing layers of drawings like facades and sections superimposed on each other.*It turns out that the shallow space the observer occupies, is a space of geometrical pattern bearing a strong connection with the space expressed in architectural drawings.*

However, it is still not clear which is the relationship between geometry, drawing and actual[61], architectural space. For if actual space from the exterior offers instant access to geometrical properties the question is whether this access is offered from other view points. Besides, only a partial view of this

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60 As Margaret Hagen has shown apart from Cubism Egyptian art and the art of the Indians of the Northwest Coast have used multiple station points. Margaret Hagen, 'Varieties of Realism', Cambridge University Press, 1986, p. 157, 168, 219.

61 The term *actual* is used to signify architectural space in the form the observer encounters and occupies it physically.

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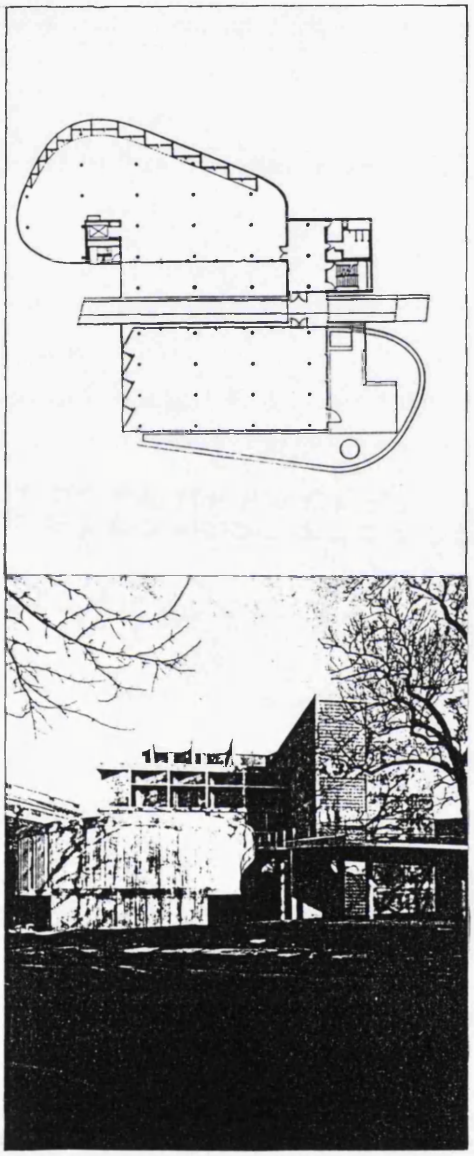

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space is captured from the frontal view point. The layered organisation of horizontal planes, for example is another aspect captured only in a drawing[62].

This is what the authors attempt to examine next by looking at how the layered space suggested from the exterior determines the internal organisation. This organisation is opposing layering through the direction of the dividing walls that enclose a major volume at right angles to the facade. However, the cantilevered slots, the apse of the dinning room, the void and the library approximate the division of space as implied by the planes. Thus, there is a constant tension between *'actual'* and *'inferred'* space. 'There is a continuous dialectic between fact and implication. The reality of deep space is constantly opposed to the inference of shallow' [63].

Thus, Rowe and Slutzky point at the difference between shallow and deep space generating a tension between inference and implication, i.e. what one *is aware of* and what *actually exists.* Deep space identifies with the interior volume extending at right angles to the facade. Shallow space identifies with geometry. Therefore, deep space refers to the ways the observer physically encounters space as a serial experience of spatial points, that cannot be occupied simultaneously, i.e. with actual space. Shallow space identifies with the ways the observer captures the arrangement of these points synchronically in the shallow datum of geometry.

It seems that the tension between shallow and deep space in Villa Stein *is a tension between views allowing access to the geometrical properties of elements prior to their locations in actual space and views that deny this access redistributing them into their positions in this space.*

Rudolf Arnheim is also concerned with how Le Corbusier's Carpenter Centre of the Visual Arts at Harvard University is captured as a geometrical scheme as one moves towards and inside the building. Each horizontal level provides only fractured information about the two kidney shaped studios that are located at different levels. Thus, the horizontal experience of the two kidney-shaped studios or the exterior views of the building allow only a very elementary guess of its 'structural skeleton', (illustration 1.24).

'In order to grasp that basic scheme one must realise that a central cubic core, externally reflected by the equally cubic staircase tower, constitutes the spine of the building and bears the horizontal wings as a tree trunk bears its branches. Some such image of the interrelation of the vertical and horizontal elements is indispensable for the most basic understanding of what faces the visitor when he approaches Le Corbusier's creation'[64].

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62 This is because only in drawing the horizontal layers can be seen as travelling behind each other. In actual space an observer would not be able to see how the layers above or behind each individual floor are arranged.

63 Ibid., p. 170.

64 Rudolf Arnheim, 'The Dynamics of Architectural Form', University of California Press, 1977, p. 59.

Arnheim proposes that to understand how the series of fractured information provided as one moves around the building or inside each floor relate along the vertical direction one has to capture a geometrical schema. Intelligibility seems, thus, to develop through movement relying on tests of the information received from different positions against this schema.

Maurice Besset also suggests that Le Corbusier intended to integrate movement into the experience of his architecture. He proposes that the 'virtual mobility' implied by the Cubists through the depiction of an object from various points of view was transposed to the plane of architecture[65]. Architecture was able to break away from the axes and static symmetries of the past and integrate the 'sum total experience of building'. Nevertheless, understanding as implied by Arnheim is based on hypotheses about geometry tested rather than accumulated as a sum of visual information obtained from different points of view.

- **Actual and projective form**

The discussion so far has been based on how geometry relates to actual space. The question raised at this section is how they both relate to drawing.

Unlike those authors who look at how Le Corbusier established an analogy between architecture and Cubism, Evans suggests that it was Cubism which sought an analogy with architecture. This analogy was based on an identification of the 'fractured totality' of a Cubist painting with architectural drawing.

'Picasso's statement that all the facets of one of his nude portraits could be cut from the canvas and reassembled to make a full-bodied model requires that we think of the painting as a more or less intuitive version of the geometric development practised in technical drawing as if it were an anthropomorphic equivalent of Mercator's projection' [66].

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65 Maurice Besset, 'Le Corbusier, To live with the Light', editions d'art, abert Skira, 1987, p. 40. This suggestion was first introduced by Sigfried Giedeon. Assuming a correspondence between painting and architecture Giedeon proposed that the planar and fractured simultaneity of cubist painting is comparable to the planar and transparent surfaces of the Bauhaus wing. Establishing an analogy between architecture, painting and Einstein's theory of relativity Giedeon suggested that the simultaneity of fractured images in paintings and the simultaneity of inside and outside produced by the glazed panels of the Bauhaus were expressing a totality known only through time, Sigfried Giedeon, 'Space, Time and Architecture', Harvard University Press, 1967.

66 This analogy was based on an attempt to break away with what was thought a Euclidean distorted reality, i.e. perspective. Ironically, as Evans suggests, the cubist painters chose architectural drawing which is more like Euclidean geometry, Robin Evans, Ibid., p. 62.

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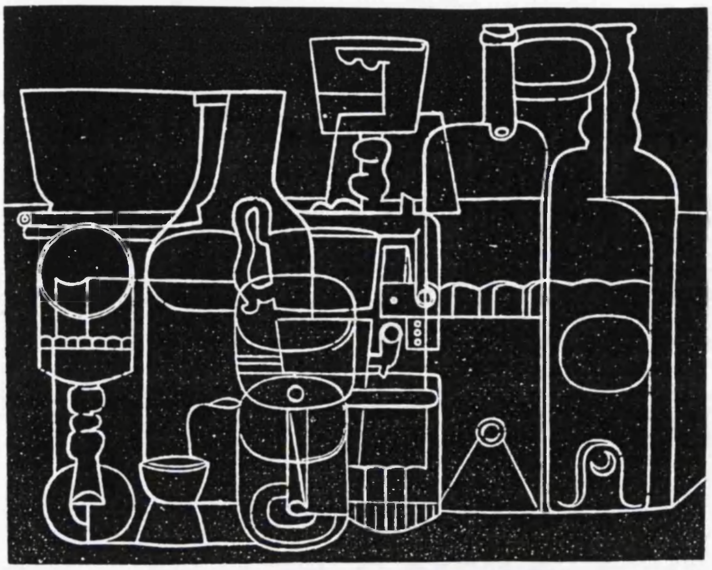

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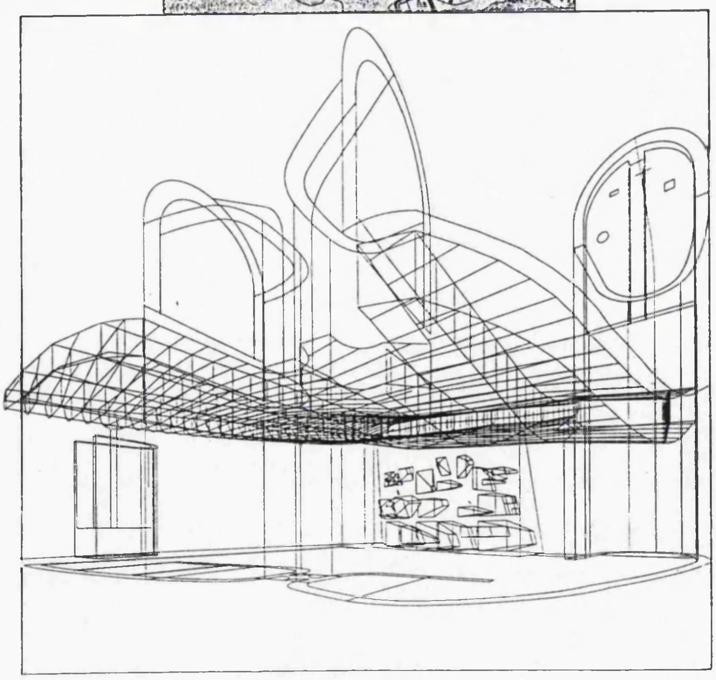

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Evan's suggestion seems to be reaffirmed if one looks not only at Cubism but also at Le Corbusier's purist paintings, (illustration 1.25). The sharp contours of the transparent objects in the painting bring them closer to the precision of architectural line drawing. The superimposed frontal and top views resemble superimposed architectural plans and sections. Sections through these objects are overlaid to provide a total synthesis of visual information assembled from different spatial positions.

Arnheim suggests that overlays are necessary to understand not a pictorial scene but a complex object like the human body or a building by Le Corbusier. A superimposition of two plans taken from different levels is required to grasp Le Corbusier's synthesis of two kidney-shaped spaces located at different levels in the Carpenter Centre[67]. Thus, the plan is sometimes inadequate in providing information about its basic compositional schema. It can also be inadequate in presenting the complexities of what one sees moving in space. The sculptural qualities of Ronchamp along the vertical direction, for example, are in contrast with the simplicity of its footprint on the ground[68], (illustration 1.26).

However, there are cases in which the plan might provide enough information. As Trevisiol suggests Botta's plan implies the spatial articulation. 'The geometrical element which Botta stresses in his drawings ... perfectly translates the perception of space which his architecture evokes' [69]. 'The plan is the central moment of the composition, in the sense that the synthesis of spaces is already implicit in its articulation'[70]. Botta's plan is so revealing that the other characteristics of volume, section and elevation emerge from it.

*Summarising, according to these authors Le Corbusier's plans express neither the compositional schema nor the experience of the observer in space. On the other hand the plans of Botta are capable of expressing both compositional and actual space.*

- **Generic and specific form**

The contribution of the above authors to the subject of this research lies in the identification of geometry as a complex system of relationships that brings together elements distant in space. This system allows one to organise the serial information received in this space.

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67 Rudolf Arnheim, ibid., p. 107.

68 Arnheim suggests that the combination of plan and section, reveals the combination of the total sum of activity along the horizontal to the 'principal terrain of vision' occurring along the vertical direction. The deficiency of the architectural drawing makes the superimposition necessary while at the same time conforms with the information received by the human eye as flat projection in the retina. Ibid., p. 59.

69 Robert Trevisiol, Ibid., p. 81.

70 Robert Trevisiol, Ibid., p. 98.

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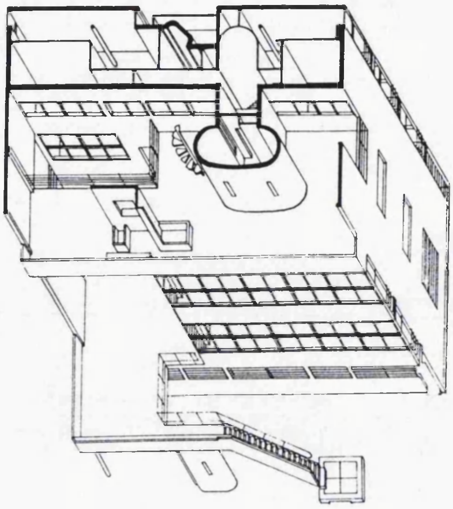

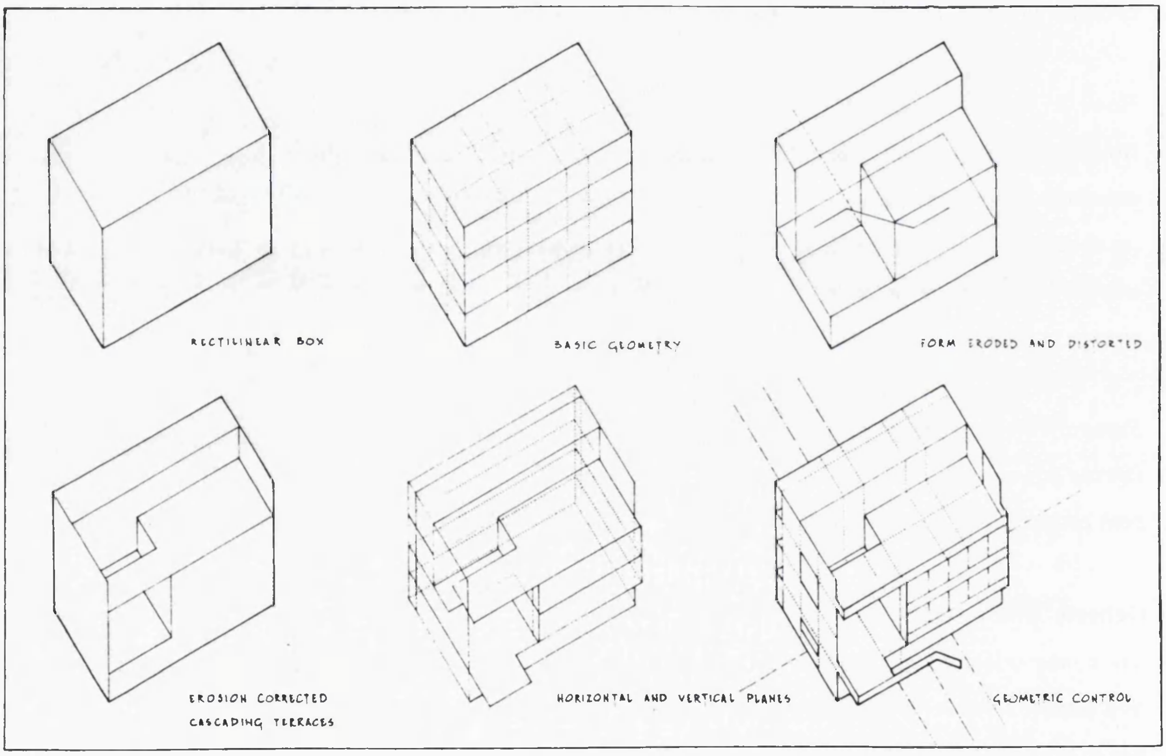

RECTILINEAR BOX
BASIC GEOMETRY
FORM ERODED AND DISTORTED
EROSION CORRECTED
CASCADING TERRACES
HORIZONTAL AND VERTICAL PLANES
GEOMETRIC CONTROL


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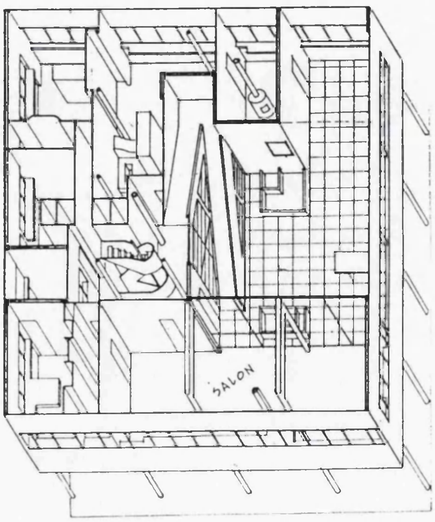

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*However, these authors seem more preoccupied with the ways geometrical relations are grasped and less with the relations themselves.* Their descriptions are based on scattered observations about the organisation of grids, elevations and plans. They do not, therefore, provide a systematic description of geometrical properties of a building as a whole.

Geoffrey Baker looking at Le Corbusier's architecture concentrates on the description of geometrical properties prior to the ways these are understood in space. His interest, thus, lies mainly in how these properties are intelligible in themselves[71]. Before focusing on how the geometry of the grid is expressed in the facades, plans and space Baker examines the articulation of the volume. This is based on a transformation of a rectilinear block, a 'gestalt slab'[72], from a generic to a *specific form.*

*Generic form* results from a reduction of the building into an elementary geometrical solid like a rectangle or a cube. *Specific form* is the building itself with its various degrees of articulation[73]. Thus, Baker's description of the volume as a transformation from generic to specific form is a step by step generation of the external appearance of a building.

During this generation in-between stages descending from the generic to the specific level are defined. In this way, a total set of geometrical relations employed during a transformation process are gradually obtained. These relations are seen as differentiations from the primary pattern.

In Villa Stein transformation on the one hand produces an 'eroded' slab by a large excavation at one corner, while on the other it 'restores' the slab by an extension of its horizontal and vertical planes, (illustration 1.27). However the missing corner cannot fully reconstruct the slab. Thus, all stages following the generic stage are characterised by a contrast between the distorted block and the symmetrical format of the grid.

This contrast results in a diagonal organisation of the plan and an asymmetrical organisation of the facades. However, regardless of the asymmetrical facade, components like the canopy, the small balcony and the terrace at the front facade assert the symmetrical format of the grid. In Villa Savoie the same contrast characterises the orthogonal grid, the simple elevated volume, the roof planes, the curved ground floor and the diagonal organisation of the piano nobile[74], (illustration 1.28).

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71 Geoffrey Baker, 'Le Corbusier, An Analysis of Form', Van Nostrand Reinold, 1989.

72 Ibid., p. 183.

73 The notions of generic and specific form are borrowed from Eisenman. Generic form is 'form thought in the Platonic sense, as a definable entity with its own inherent laws'. Specific form is 'the actual physical configuration realised as a result of a specific intent and function'. Peter Eisenman, 'Towards an Understanding of Form in Architecture', Architectural Design, London, October 1963, p.p. 457-458.

74 Ibid., p.p. 194-213.

In villa Stein a conflict is also created between the regular grid, the asymmetrical entry and the diagonal direction of movement. In Villa Savoie this conflict is based on the curved access route, the linear ramp and the continuous movement throughout the house. These routes constitute a dynamic experience of a sequential nature 'that becomes the thread which holds the design together, and Le Corbusier cross-references the various relationships of elements with the way these are perceived along the movement route'[75].

Similarly to Rowe, Baker observes a tension between regularity and distortion in Le Corbusier's houses. Nevertheless, the novelty of Baker's approach lies less in the identification of these principles and more in the analysis of the volume. Looking at the volumetric articulation as a process of transformation, he proceeds from a simple geometrical shape down to local levels of articulation. The ways these levels relate to the first one determine the relationships between the whole and the parts.

This analysis progresses systematically not only from generic to specific state but also from the volume to the elevations, sections and plans. There is an implicit suggestion, that there is an overall logic governing the volume and affecting its horizontal and vertical structuring.

Therefore, whereas the authors considered before isolate and examine these systems as static entities, Baker sees them as dynamic ones resulting from the volumetric articulation. Whereas these authors dissect form to its individual components, Baker dissects it to its states of genesis allowing the 'intuitive processes which inform the final work'[76] to be revealed.

Baker is aware that his process of genesis does not reconstruct the temporal process in which Le Corbusier designed his buildings. The significance of his approach does not depend on the definition of design stages but on the definition of the internal laws shaping and directing the design process. *Thus, his description becomes a description of properties as well as of the constructibility of this process.*

Baker suggests that Le Corbusier's buildings are understood as erosions, distortions and transformations of a box. Thus, the geometrical properties of the building are grasped as variations from a constant. What follows from his description is that intelligibility depends on transformations of an elementary geometrical concept. It is defined as an extrapolation of a geometrical structure governing levels of order between simple and complex geometrical systems.

However, Baker's analysis stays mainly at the level of geometrical properties. He does not explain how these properties are understood by a mobile observer. Although he suggests that the routes are the threads

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75 Ibid., p. 211.

76 Ibid., preface.

that hold the elements of design together, he does not provide a description of the properties of these routes and of how they interact with the geometrical elements.

- **COMPARATIVE EXAMINATION OF THEORIES**

At this stage a comparison of the theories presented up to now is attempted. The aim is to see how the discussion of the above authors enable this research to answer the following questions:

- Is it possible to draw a first hypothesis regarding the ways geometry clarifies intelligibility during spatial experience in the architecture of Le Corbusier and Botta?

- Is it possible to establish a clearer definition of the research problem?

- Which are the questions that these theories leave open? These questions would seem to lead towards a definition of the area this research attempts to cover.

The discussion of the existing literature at this stage points to a distinction between *what architecture refers to* and *what architecture is made of.* Critics either discuss Le Corbusier's and Botta's architecture in terms of its properties to carry meanings based on cultural convention or they look at those aspects that can be considered as quantifiable and objective. The former discuss what architecture 'talks about' drawing an analogy with language, while the latter discuss what architecture 'is made of' drawing an analogy with mathematics and geometry.

This distinction generates two different approaches to architectural form and its role in intelligibility. For those claiming that intelligibility relies on cultural meaning architectural form identifies with a simple geometrical shape, the overall form of a building. Thus, the geometrical structure of Le Corbusier's and Botta's houses deserves little attention apart from this shape. For those that consider that intelligibility is based on the internal laws of architecture, geometry is the first issue to be addressed. These theories usually see form as a complex system of geometrical relationships.

Thus, from the theories of linguistic analogy to the theories of mathematical analogy the description of architectural form moves from simple to more complicated geometrical concepts. Both theories will be discussed in the following section dealing with intelligibility in the general context of architecture. However, theories concentrating on the objective and quantifiable properties of Le Corbusier and Botta's buildings are examined at this point also with a view to answer the questions set above.

- **Theories of abstract and theories of visual geometrical pattern**

These theories take also two directions. One looks at buildings as products of proportions and platonic solids, (Wittkower, Sartoris), whereas the other looks at them as products of complex geometrical relations, (Arnheim, Evans, Rowe, Nicolin, Zardini and Baker). The former examines abstract proportional relations and geometrical shapes independently of the ways they are captured by an observer in space. The latter examines the ways geometrical relations qualify for a visual experience.

Thus, although the former see mathematical and geometrical order as an essential parameter for intelligibility, they do not explain how it affects the observer's capacity to read and understand architecture. On the other hand, the latter explore the ways geometrical relations are embedded in architectural space.

In Botta geometry can be visually identified governing relations amongst physical elements from the level of the volume to the level of the facades, (Nicolin, Zardini). In Le Corbusier geometry stays hidden behind the immaterial structural framework and the complexities of the layout, (Rowe, Baker). Occasionally it is pulled up to the threshold of visual awareness, by being locally asserted by small incidents in both plan and elevation. Thus, according to these authors there are cases in which geometry is clearly expressed in physical systems, and cases in which there is no effort to make it clear. On the contrary, it resists exposure staying half hidden/half expressed by physical elements.

- **The synchronous plane of geometry and the diachronous plane of spatial experience**

The relationship between geometry and experience is explored further by authors who implicitly or explicitly involve in their description a mobile observer, (Zardini, Rowe and Slutzky). For Rowe and Slutzky this relationship is translated into a relationship between shallow and actual space. The former operates at the shallow plane of geometry. The latter operates at the actual plane of space. In the former elements are dislocated from their distant positions in space and squashed into a perceptual flatness. In the latter elements step out from the shallow plane to find their actual distances in space.

In Le Corbusier there are moments in which the shallow plane is revealed from a single station point of view. The necessity to cover other view points is, thus, reduced. There are also moments in which the shallow plane is contradicted by the actual plane. For Arnheim the shallow plane is a compositional schema the observer relies on to test the fractured information he receives moving inside Le Corbusier's buildings. Thus, the shallow plane clarifies relations that are sequentially grasped in the plane of actual space.

What follows from these suggestions is that intelligibility in Le Corbusier is based on a hypothesis testing process in which access to geometry offered from certain points is tested against what is seen from other points. What is captured from one position is not reaffirmed by what is seen from another one. *Thus, to understand a building by Le Corbusier the observer is required to move and exchange positions in space.*

Moving from Le Corbusier to Botta the ideas put forward by Nicolin and Zardini could be extended to see how an observer moving in space can comprehend the geometrical properties of his houses. The authors suggest that the organisation of facade and volume express the geometrical ordering of the building as a whole. Thus, it seems that standing in front of a facade of a house by Botta, one can capture a volumetric centrality.

In the interior, the detachment of the walls from the ceiling, the absence of doors and the vertical perforation of the floors enable one to understand the unification of the loggias, the skylight and the stairs into a single central system as well as the conception of the house as a unified space. Thus, one can grasp the unity and the symmetrical organisation of the volume. According to Zardini and Nicolin the geometrical scheme inferred from the exterior is reaffirmed from the interior.

*It turns out that in Le Corbusier there is a contrast between what is captured from the exterior and what is captured from the interior. In Botta interior and exterior reaffirm each other. In Le Corbusier serial information in space contrasts the simultaneous information of geometry. In Botta no such contrast exists allowing the latter to manifest itself in the former.*

This observation leads to the following question: *what determines the lack of tension between geometry and spatial experience in Botta and the existence of this tension in Le Corbusier?*

- **Drawing and spatial experience**

The notion of shallow space pointed to a distinction between space and architectural drawing. This distinction was also introduced at the beginning of this thesis through an examination of some basic configurations. Elaborating further on the difference between drawings and buildings it could be said that in a drawing space is statically seen. In reality it is dynamically seen through movement and observation. In a drawing it is seen at a single glance. In reality it is seen as a dynamic set of visual fields that are confined within what is accessible to the eye. In a drawing the visual field is always the same. In reality the visual field constantly changes. In a drawing seeing, aided by the static characteristics of the visual field, becomes straightforward. In reality it is integrated within the complex experience of movement and is, thus, sequential.

What follows from these considerations is that while drawing can allow access to certain aspects of geometrical properties at once, space articulates access gradually. The former offers access to maximum information from a single vantage point, whereas the latter from a multiplicity of points. The former assists a detachment of shapes from the picture plane creating the illusion of depth, whereas the latter assists a detachment of the observer from his vantage points to comprehend the condition of shallowness.

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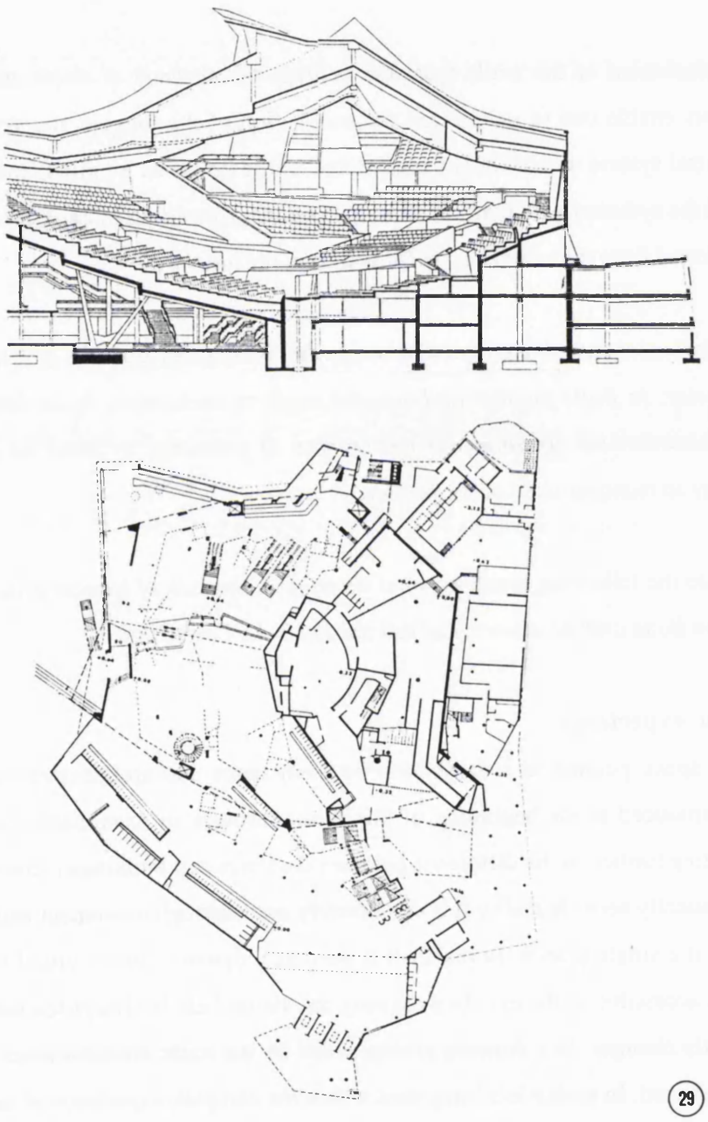

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*Thus, drawing is a synchronous plane recording geometrical relations amongst elements that are seen from different points of view in actual space.*

However, Arnheim and Evans question the role of the architectural drawing in capturing geometry and spatial experience[77]. The complicated surfaces and spaces of buildings like Le Corbusier's Ronchamp or Scharoun's Philarmonie, (illustration 1.29), cannot be expressed by plans or sections. Seeing through drawings is 'less tied to experience than the classical section had been, and anything but economical'.

Nevertheless, for Evans drawing in architecture is an instrument of construction and a means of visualisation. 'It is not so much produced by reflection on the reality outside the drawing, as productive of a reality that will end up outside drawing'[78]. In classical architecture the axis of symmetry recorded in plan, section and elevation expresses the central processional axis in space. This enabled architects to visualise a classical building while designing.

As Evans suggests modern architecture broke away from the right angle, frontality, geometrical coherence and unity necessary to visualise space during its creation. The above properties, widely used in classical architecture, brought about a correspondence between drawing and building. Thus, for Evans the ability of the drawing to express compositional and actual space lies in the kind of geometrical properties used.

*In this context, it seems that the employment of geometrical unity by Botta enables geometry to be expressed in both drawings and spatial experience. On the other hand, the lack of such unifying principle in Le Corbusier makes both drawings and spatial experience unable to communicate at once the properties of geometry.*

The fundamental distinction between drawings and buildings seems to reconfirm what an initial examination between carried out at the beginning of this study suggested: an analysis of the ways geometry relates to the experience of actual space should distinguish between an analysis of geometry as embedded in drawing and an analysis of geometry as embedded in the experience of space. Besides, a distinction should be made between space as expressed in drawings and as experienced in reality. This way, the ambiguities of what is seen in drawing and what in reality presented by the authors examined before, could be overcome allowing for a comparison between the synchronous plane of geometry and the diachronous plane of spatial experience.

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77 Rudolf Arnheim, Ibid., p.59, Robin Evans, 'Translation from Drawing to Building', AA Files, no 12, p. 3-17.

78 Robin Evans, ibid., p. 7.

- **Geometry as a transformation process**

Baker aware of the difference between a description of geometry and a description of the ways it interferes in spatial experience, focuses on geometrical properties prior to the ways these are understood in space. He also takes the description of these properties in a new direction. His analysis develops from the volume to the elevation and plan, from the simple to the complex and from the generic to the specific state. Intelligibility is based on systematic relationships in which elements are recognised only in terms of how they are linked with a higher order geometrical concept.

Baker's description becomes also a description of construction, of a genesis of form. It is, thus, fundamentally linked with the notion of composition. What follows from a simultaneous description of geometrical properties and design operations is that the same parameters determining intelligibility of a building determine its intelligibility during the process of making. *If geometry transmits its meaning through the embodiment of its transformation, this is the way it transmits its meaning to the designer during the process of making.*

This approach of looking at how a complex geometrical system approximates or differentiates from a simple geometrical concept, seems similar to Arnheim's notion of 'geometrical simplicity'. Arnheim associated 'geometrical simplicity' with the notion of 'wholeness'. A 'whole' is a geometrical system in which laws are hierarchically applied from simple to complex levels of articulation.

'Such wholes do not grow like unplanned cities- making the whole chaotic. Organised wholes grow by differentiation of a germ structure, and its detail is determined by the law of the whole. This means they have layers of order, which descend from the highest and simplest to the more and more complex ones. The order found at each level is true'[79].

For Arnheim these wholes are compositional schemata the architect starts his work with and manipulates at will to arrive at differentiations. These are the same schemata that an observer uses to organise the fractures information he receives moving in space. Baker calls these wholes generic forms the architect articulates, breaks, erodes or restores during the process of making. These forms inform the spatial experience which unfolds inside their eroded or restored format. Thus, the notion of an elementary configuration like a simple geometrical shape becomes crucial for both design and intelligibility in space for these theorists also.

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79 Rudolf Arnheim, Ibid., p. 116.

- **SUMMARY AND CONCLUSIONS FROM PART ONE**

- **Geometrical unity and intelligibility - Reformulating the research question**

The examination of the two architects by these authors shows that, regardless of whether form identifies with elementary or complex geometrical concepts, it becomes intrinsically related with the notion of geometry. *Thus, the question of the ways properties of form are experienced in space becomes a question of the ways geometrical properties become intelligible.*

Besides, the examination of the two architects shows that geometry and spatial experience create either an accordance or a tension between a synchronous and a sequential plane. The above considerations can, thus, lead to a redefinition of the research question as following:

- *How do relations operating at the synchronous plane of geometry clarify relations operating at the sequential plane of spatial experience?*

The examination of these architects by the above authors enables also a first hypothesis regarding the ways geometry clarifies intelligibility during spatial experience in the architecture of Le Corbusier and Botta:

- *The tension between regularity and irregularity in Le Corbusier generates a tension between the two planes. In Botta geometrical symmetry and unity creates a correspondence between them.*

The notion of geometrical unity seems persistent in both theories of linguistic and geometrical analogy. From Colquhoun and von Moos to Sartoris Le Corbusier's and Botta's buildings are discussed in terms of their ability to register as simple geometrical shapes. This shows a profound belief that what intelligibility is about is a geometrical unity, a kind of wholeness that makes the identification of this shape possible.

The significance of geometrical unity is persistent amongst those who discuss form as a complex set of geometrical relations also. For Arnheim, Rowe and Baker it becomes a prerequisite to measure not only buildings that are based on it, like Botta's houses, but also buildings that deviate from it, like Le Corbusier's houses. Notions like 'diffusion', 'distortion' and 'erosion', used by these authors to describe Le Corbusier, describe form as something possessing a unity that becomes systematically broken, diffused and distorted.

The questions that arise at this point are :

- *Does geometrical unity affect the intelligibility of buildings in a way that they can be easily understood? How can buildings that are not characterised by it become intelligible?*

- *If the notion of a simple geometrical shape as capturing this unity is not enough to describe the complex geometrical relationships even in buildings that look simple like Botta's houses how is a description of unity that encompasses geometrical complexity possible?*

- *How can description capture relationships in which this unity is disintegrated, like in Le Corbusier's houses?*

The above theories cannot offer an answer to these questions. This is because they do not provide a tool for analysing geometrical properties as well as the ways they structure spatial experience. They cannot offer a description of what constitutes spatial experience and what kind of a role geometry plays in this experience either. Baker seems to define a way to analyse Le Corbusier's volumes. However, his analysis of space is limited to local observations. These refer to the ways circulation routes intensify the contrasts between the decomposition of the volume and the regular geometrical grid. Thus, it cannot contribute to a clear understanding of how experience develops in space as well as of how geometry enables the viewer to comprehend this space.

The following sections will attempt to extend the examination of the research problem to see how it is covered by a more general theoretical discourse. They will also test the theoretical significance of this problem, of the hypothesis and the observations drawn in this section. Finally, they will attempt to answer the questions raised so far leading also to the development of an analytical model for dealing with the relationship between the synchronous plane of geometry and the diachronous plane of space.

- **PART TWO**
- **FORM AND INTELLIGIBILITY IN ARCHITECTURE**
- **ARCHITECTURE AND ITS ANALOGY TO LANGUAGE**

Writers that interpret Le Corbusier's and Botta's work in terms of what it refers to, see architecture as an assimilation of elements outside itself. They look rather at what meanings are attached to buildings, than at how relations are formed to create meanings. As it was suggested, these interpretations often take two directions: one sees architecture as an interaction of formal and figurative themes, while the other as an interaction of formal and functional themes.

As it was also suggested these approaches usually draw an analogy between architecture and language. This analogy for Peter Collins is founded on the fact that they both have functional and emotional significance that develops through time[80]. They are both characterised by the notion of grammar, the notion of distinction between vocabulary and syntax, and the notion of ornamentation and structure.

Linguistic analogy is based on Saussure's distinction between *langue* and *parole.* It is also based on the notion of the 'arbitrariness of the sign'[81]. Saussure suggested that the linguistic sign takes its meaning from social convention and not from reason. It was, thus, liberated from the problem of causality and determinism. Departing from the linguistic model, a semiotic theory was established attempting to interpret various social phenomena. An area in research and architectural practice opened in recent years concerned with the 'architectural semiotics' and transposing linguistic models to architecture. These models provide a way to justify design decisions that are not founded on pre - established meanings and social purposes.

At the level of theory there have been various linguistic directions, the majority of which, as Donald Preziosi points out, assume that architecture exists as a 'lexical label or certain arbitrarily restricted artifactual portions of the built environment...'[82]. Thus, architecture is often described as a system of signs which is delivered by word-like elements. This is demonstrated by Colquhoun's distinction between meaningless form and meaningful figure or by Mario Galdesonas' description of the Renaissance architecture as 'an apparently finite and stable number of forms and their correlated meaning within a

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80 Peter Collins, 'Changing Ideas in Modern Architecture', 1750-1950', Faber & Faber, London 1965, p.p. 173-182.

81 Ferdinard de Saussure, 'Course in General Linguistics', trans. by Wade Baskin, New York, McGraw-Hill, 1966.

82 Donald Preziosi, 'Architecture, Language and Meaning', Mouton Publishers, 1979, p. 3.

closed system'[83]. Although Galdesonas distinguishes between a 'syntactic' structure of language, dealing with its syntax, and a 'semantic' structure, dealing with its meaning, his particular definition is from the point of view of word - like elements.

As the discussion of theorists like Colquhoun, von Moos, Tzonis, Lefaivre and Trevisiol showed, architectural semiotics often looks not at the architectural syntax but at arbitrarily selected portions, like individual architectural entities, or fragments of a canon, or prominent building types that identify a building form with a specific function or meaning.

Another example of a theory based on linguistic analogy is Bruno Zevi's review of modern architecture as language in which configuration of certain individual elements changes from Classicism to Modernism[84]. Charles Jenks' 'The Post Modern Language of Architecture'[85] and Robert Venturi's 'Complexity and Contradiction in Modern Architecture'[86] are also examples of the same assumption. Venturi stresses that architecture is a process of accommodation of semantic complexities enhanced by ambiguities and contradictions. Past styles are available for re-use as conventional elements that become vital through distortion, so that old and new meanings coexist and reinforce each other.

Venturi, Scott Brown and Izenour extended this idea further taking the emphasis from the ambiguous and 'difficult wholes' to the idea of the 'decorated shed'. According to this idea, the architects' attention should shift from space and structure to symbolic content[87]. The road from architecture to content lies in making concrete the internalised value systems of the users.

At the level of architectural practice, this approach enabled the questioning of modernism with its insistence on functionalism on the one hand, and the break up of the traditional system of cultural signs on the other. It gave rise to different ways of responding to the linguistic analogy ranging from Charles Moore's and Robert Venturi's use of 'isolated lexical figures' [88] to Aldo Rossi's and Giorgio Grassi's use of 'archetypal' forms as the most representative of the collective experience of architecture.

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83 Mario Galdesonas, 'From Structure to Subject: The Formation of an Architectural Language', introduction to Peter Eisenman's book, 'House X', Rizzoli International Publications, Incl. 1982, p. 7.

84 Bruno Zevi, 'The Modern Language of Architecture', University of Washinghton Press, 1978

85 Charles Jenks, 'The Post-Modern Language of Architecture'

86 Robert Venturi, 'Complexity and Contradiction in Architecture', New York: The Museum of Modern Art, Doubleday & Co., 1966.

87 Robert Venturi, Denise Scott Brown and Steven Izenour, 'Learning from Las Vegas', MIT Press, 1972.

88 Alan Colquhoun, 'Essays in Architectural Criticism', The MIT Press, 1985, p. 198.

It is beyond the scope of this research to give an extensive account of linguistic analogy as well as of its application in architectural practice. However, a basic criticism is attempted, to demonstrate the difficulties inherent in this approach.

Roger Scruton suggests that language and architecture have grammatical constraints and intention in common[89]. 'The relation of words to their meaning is not natural but intended...'. Besides, 'Buildings, like linguistic utterances, are in all their particulars intentional and must be seen and understood as such'. However, the former is preoccupied with semantics that becomes acceptable by its reference to 'truth'. The latter is not concerned with semantics because there is no clear cut relationship between the expression of a function or an idea and the true possession of them. According to Scruton 'to denote a function is not the same as to possess a function'.

In-spite of his linguistic approach to architecture, Colquhoun attempts to show its limits, by pointing to changes in the semantic values of architectural qualities from one culture to the other[90]. He suggests that architectural signs are 'motivated' rather than arbitrary. Whereas in language change is unintentional, in architecture is always intentional. What is interesting in language is the meanings attached to phonic objects as opposed to architecture where is the objects themselves[91].

Von Moos also points at the importance of the formal parameters in Le Corbusier's work. He stresses the vague and flimsy nature of the functional symbol suggesting that Le Corbusier's forms were incapable of signifying specific functions.

Trevisiol's account of Botta also oscillates between linguistic interpretations and architecture's capacity to be preoccupied with its own structure. As he says the geometrical simplicity of Botta's drawings demonstrates the 'possibility - the necessity even - of architectural independence'[92].

Galdesonas' identification of architecture with a set of forms that carry certain meaning is also contradicted by an observation similar to Colquhoun's. The relationship of architecture to language is

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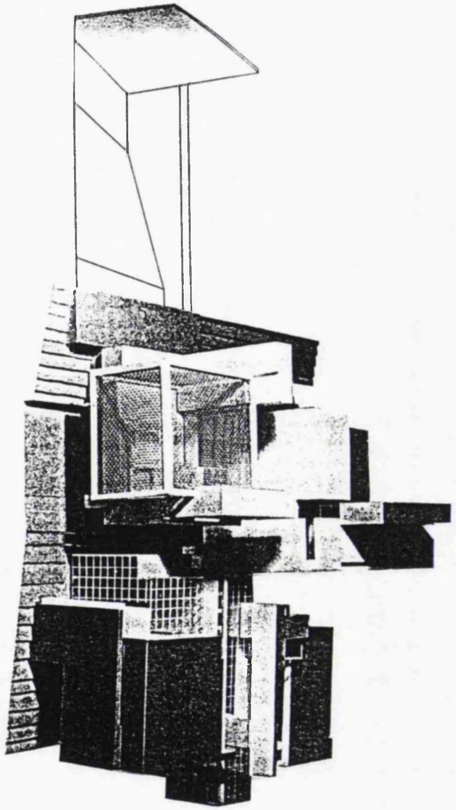
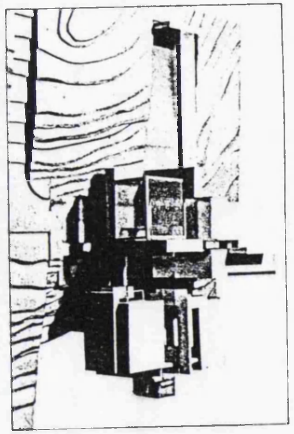
89 Roger Scruton 'The Aesthetics of Architecture', Methuen & Co. LTD, 1979, p.p. 158-178.

90 Alan Colquhoun, Ibid., p. 130.

91 However, Colquhoun's opposition to semiotics focuses on Saussure's notion of the synchronic analysis of language and serves the purposes of showing the cultural strength of figures in a diachronic context. Cultural meaning is given to figures by society and they have to be examined within a diachronic context in which they change in a way that 'the form of one system becomes the content of the next higher system', Ibid. p.p. 129-138.

92 Robert Trevisiol, Ibid., p. 82.





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imprecise because architectural signs are not fixed and socially acceptable facts. The same forms might have different meanings in different periods[93].

Galdesonas' analysis of Eisenman's houses points at the distinction between a 'syntactic' and the 'semantic structure'. The former concentrates on the properties of forms, whereas the latter on notions outside these forms. In his criticism of Eisenman's work Galdesonas points at his shift from an architecture of pure syntax and 'composition' characterising his early work to an architecture of the *semantics of syntax* and 'decomposition' characterising House X, (illustration 1.30).

In the former, a formal domain is structured according to certain rules and prescribing a certain course of action. In the latter, shapes and forms are fragments that represent the elements of a Cartesian system and of a formal unity no longer present in his work. The former addresses the user's capacity to read visual configuration. The latter symbolises through fragments that there is no unity between design and interpretation.

Thus, Galdesonas demonstrates that syntax opens to intelligibility whereas semantics opens to symbolism. The former demonstrates how meaning is possible, the latter, in Eisenman's work, symbolises that meaning is impossible. *Thus, if meaning is possible through syntax, then the understanding of architecture cannot be simply based on the semantic level of description.*

For Bill Hillier and Julienne Hanson architecture is similar to language from the point of view of 'being creatively used for social purposes, and of permitting a rule governed creativity'[94]. Defining architecture as a *morphic language* Hillier and Hanson attempt to incorporate both syntax and meaning into a single theoretical framework. Meaning does not derive from extrinsic associations but from syntax itself.

Thus, the search for meanings rather than stressing signification should stress the primacy of significance[95]. Signification is concerned with what architecture stands for outside itself, 'much in the way that a word used in the proper place and in the proper grammatical context can convey a meaning which is outside language rather than integral to it'[96]. Significance refers to architectural form 'compared to other architectural forms in the context of all architectural forms'. As Hillier suggests a theory of

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93 Alan Colquhoun, ibid., p. 10.

94 Bill Hillier, Julienne Hanson, 'The Social Logic of Space', Cambridge University Press, 1984, p. 49.

95 'Common sense would suggest that a theory of the social signification of architecture can be based on a theory of its significance in itself in the first place. We must, if you like, have a theory of how architecture can mean anything at all before we can have a theory of what architecture might actually mean'. Bill Hillier, 'Quite Unlike the Pleasures of Scratching', 9H, 1985, p. 66.

96 Bill Hillier, 'Seeing Buildings: or is Architectural Form Meaningless?' Unpublished paper., 1995.

intelligibility should be based on *how* architecture is capable of having meaning at all rather than on *what meanings* it carries.

The problem with the linguistic analogy is that shifting from the object of knowledge to its interpretation, from significance to signification, it fails to account for the ways this object is shaped. As the discussion of Le Corbusier and Botta showed, architecture is a complex system of relations that determines not only how it becomes intelligible but also how it is constructed during a composition process, (Baker). Focusing on fragments of this system one cannot illuminate any of the above. One can only give a vague idea about a truss, a tympanum, a window or simply the building's overall shape.

- **ARCHITECTURE AND ITS ANALOGY TO MATHEMATICS AND GEOMETRY - Intelligibility founded on mathematical and geometrical order**

Theories approaching architecture from the point of view of its quantifiable properties often assume that its intellectual basis is mathematical and geometrical. Wittkower's conviction that the Modulor is founded on an urge for intelligibility or Sartoris' description of a building as a recognisable geometrical shape express a belief that architecture appeals to the intellect through a numerical or geometrical order.

Theories of mathematical order originate from Pythogoras' discovery of the relationship between numerical ratios and musical consonance[97]. Theories of geometrical order are based on Plato's ideas of the relation of regular solids to natural elements[98]. The most influential text these theories use is Vitruvius' 'Ten Books of Architecture'[99] . Vitruvius defines proportions using the term *symmetria* as 'a proper agreement between the members of the work itself, and relation between the different parts and the whole general scheme, in accordance with a certain part selected as standard'[100].

The Renaissance theorists and artist sought quality in architectural form in a manner similar to Vitruvius. Alberti suggested that natural excellence resides in the form of a building in a way that 'it excites the mind and is immediately recognised by it'. He defined beauty as '...that reasoned harmony of all the parts within a body, so that nothing may be added, taken away, or altered but for the worse.'[101]. He also suggested that beauty is '... a form of sympathy and consonance of the parts within the body, according

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97 Pythagoras discovered that the three simple conconances, the octave, the fifth and the fourth and the two compound consonances, the double octave and the octave plus a fifth, are arithmetically expressed by the ratios of the four integers, 1 : 2 : 3 : 4, Rudolf Wittkower, 'Architectural Principles in the Age of Humanism', Academy Editions 1988, p. 148.

98 Plato assigned each of the basic five solids, the tetrahedron, the octahedron, the hexahedron, the dodecahedron and the icosahedron to each of the five elements, i.e. the cube to the earth, the tetrahedron to fire, the octahedron to air the icosahedron to water. and the dodecahedron to the enclosing sky.

99 Vitruvius, 'The Ten Books of Architecture', trans. by Micky Morgan, Dover Publications, New York 1960.

100 Ibid. Book I, p. 14. The modern version of the word symmetry refers to bilateral symmetry in which a form has identical sides or parts on each side of an axis. Vitruvius' *symmetria* comes from the Greek word *analogia* meaning proportion. Vitruvius defines symmetria in his third book also, (the definition stated in the text comes from the first book), as the 'correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard'. ibid., Book III, p. 73.

101 Leon Battista Alberti 'On the Art of Building in Ten Books', trans. by J. Rykwert, N. Leach and R. Tavernor, The MIT Press, 1988, Book VI, p. 156.

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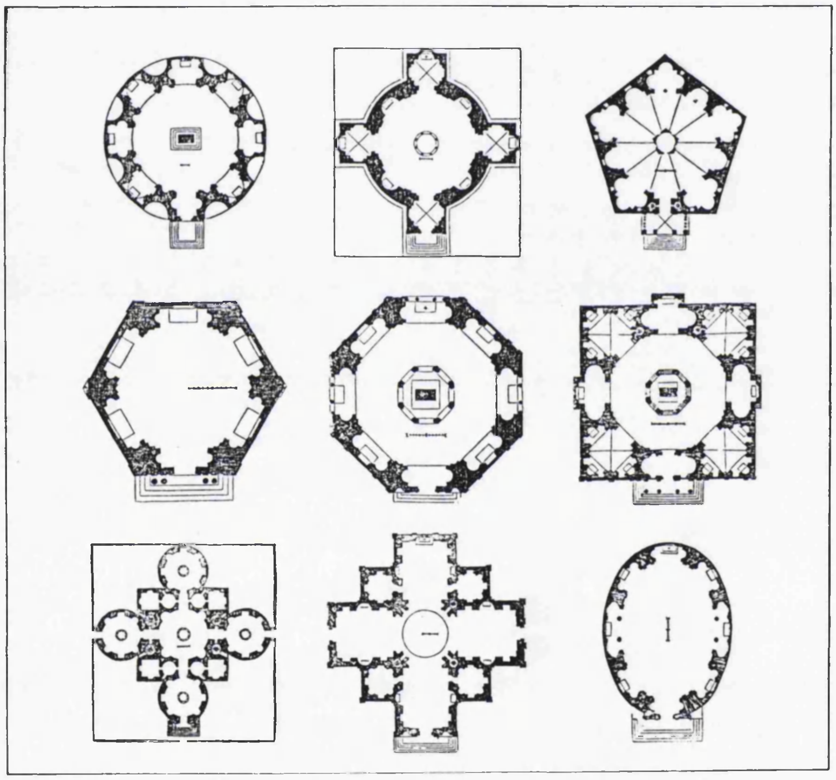

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to definite number, outline, and position, as dictated by *concinnitas*[102], the absolute and fundamental rule in Nature'[103]. Similarly to Alberti, Palladio defined beauty also as depending on proportions :

'Beauty will result from the beautiful form and from the correspondence of the whole to the parts, of the parts amongst themselves, and of these again to the whole; so that the structure may appear an entire and complete body, wherein each member agrees with the other and all members are necessary for the accomplishment of the building'[104]

The notion of proportional form was complemented by a notion of geometrical form[105]. Alberti defined geometrical form using the term *'area'*[106] as an entity enclosed by a perimeter constructed by lines and angles[107]. Using examples like the earth, the stars the animals and their nests he proposed that 'Nature delights primarily in the circle'[108]. This shape helps to generate the square, the hexagonon, the octagonon, the decagonon and the dodecagonon.

Artists like Leonardo Da Vinci, Francesco Di Giorgio and Serlio explored geometrically ordered layouts. They produced a series of drawings ranging from simple to complex configurations. These were translated to circular, square, hexagonal or octagonal plans of churches with small chapels, (illustration 1.31). As Wittkower suggests, the notion of commensurable number found perfect geometric expression in these layouts where every point in the circumference has the same relationship to the centre[109].

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102 *Concinnitas* is the successful combination of number, measure and form, (*numerous, finitio, and collocatio*), Leon Battista Alberti, Ibid., Glossary, p. 424.

103 Leon Battista Alberti, Ibid., Book IX, p. 303.

104 Andrea Palladio, 'The Four Books of Architecture', Trans. by Isaak Ware. New York: Dover, 1965, Book I.

105 Rudolf Wittkower suggests that theories of proportions and geometry are demonstrations of two different kinds of mathematical concepts. The former are concepts based on numbers, while the latter are based on basic geometrical shapes. These cannot be easily converted to arithmetical ratios because they are incommensurable. The first one was favoured during the Renaissance, while the second one during the middle ages. The preference the Renaissance architects showed in commensurable ratios was based on an organic approach to nature in which everything was related to everything else by number. Rudolf Wittkower, 'Le Corbusier's Modulor', in the book, 'In the Footsteps of Le Corbusier', Rizzioli International Publications', 1991, p. 13.

106 Leon Battista Alberti, Ibid., Book I, p. 20.

107 Rykwert, Leach and Tavernor suggest that *area* refers to the notion of the architectural plan. As such it could be seen as approximating the notion of geometrical form because architectural plans are two dimensional projections of geometrical entities. Ibid., Glossary p. 420.

108 Ibid., Book seven, p. 196.

109 Rudolf Wittkower, 'Architectural Principles in the Age of Humanism', Academy Editions, 1988, p. 18.

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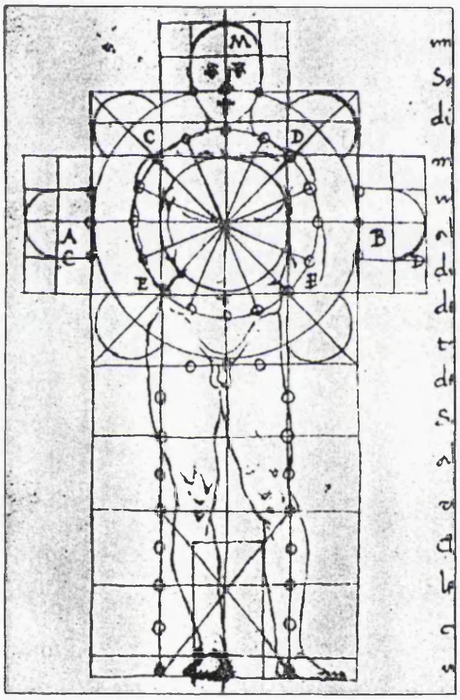


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These theories emphasised the notion of bilateral symmetry also. Alberti wrote that the parts of a building should be disposed 'with an exact correspondence as to the number, form and appearance so that the right may answer to the left, the height to the low, the similar to the similar...'[110]. Palladio also sought symmetry in the organisation of the building as the most memorable form of order.

Theories of proportions and geometry followed Vitruvius' axiomatic idea that architecture must mirror the human figure. A unit of measurement such as the head of the human body was transposed to the diameter of the column in a building establishing the metrical relationships amongst the parts and amongst the parts and the whole[111]. The geometrical analogy between the human body and architecture was used again in a series of drawings and writings exploring the relations amongst the various parts of the body and the church (illustration 1.32).

Using mathematics and geometry these theories sought the laws that intervene between nature and acts of creation like music and architecture. They often attempted combined interpretations about the microcosm and the macrocosm, nature and the man made structures under the same mathematical formula. As Barbaro suggested mathematics became the link between the 'certain truths' science is concerned with and the 'uncertain truths' of the arts[112].

Wittkower observing the correspondence between numbers, geometrical form, architecture, music, religious ideas and cosmology in the Renaissance theories suggests that commensurable proportions and the notion of the circle symbolised underlying ideas of cosmic order and harmony[113]. 'We maintain, in other words, that the forms of the Renaissance church have symbolical value or, at least, that they are charged with a particular meaning that the pure forms as such do not contain'[114].

Texts like those of Vitruvius, Alberti Palladio and Barbaro seem to show that Wittkower is right suggesting that the Renaissance theorists were manipulating certain mathematical models in different

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110 Ibid., book VI, p. 156

111 Wittkower refers to Leonardo's studies of the human figure as well as to the studies of a detail of the basis of a column by Piero della Francesca., Rudolf Wittkower, Ibid., p. 153.

112 Rudolf Wittkower, Ibid., p. 65.

113 'With the Renaissance revival of the Greek mathematical interpretation of the God and the world and invigorated by the Christian belief that Man as the image of God embodies the harmonies of the Universe, the Vitruvian figure inscribed in a square and a circle became the symbol of the mathematical sympathy between the microcosm and the macrocosm. How could the relation of Man to God be better expressed, we feel now justified in asking, than by building the house of God in accordance with the fundamental geometry of the square and the circle?', Rudolf Wittkower, Ibid., p. 25.

114 Ibid., p. 15.

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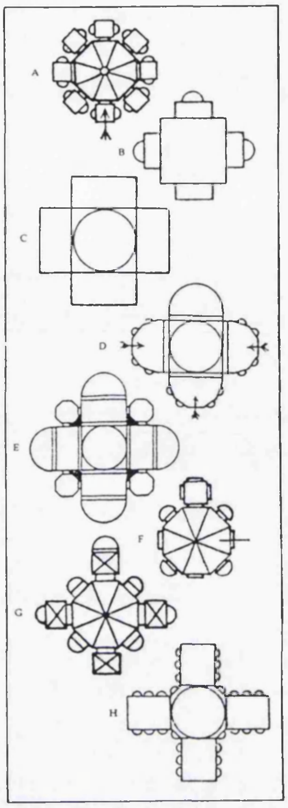


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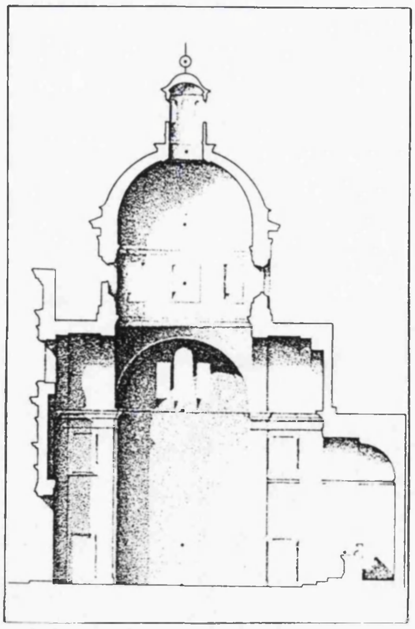

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areas of knowledge. However, Wittkower's approach to these models seems an over-simplification of both architectural form and the philosophical and religious ideas of that period[115].

Wittkower's simplification of architectural form is based on its reduction to a simple geometrical shape and to commensurable number[116]. An illustration of Renaissance plans provided by Paul Frankl[117] shows that even the most diagrammatic drawings of this period are not about a simple geometrical shape like a circle, (illustration 1.33). They seem to be about a geometrical structure of shapes the centres of which are co-ordinated by the axes covering the geometrical centre of the largest shape in the middle.

Frankl's studies of the centralised churches show that the development of geometrical form was complemented by a development of circulation systems. Some of these systems favoured a circular movement passing through the ancillary spaces apart from the movement crossing the central space. Others eliminated peripheral movement so that one returns to the focal space in order to move from one ancillary space to the other[118].

In a reaction to Wittkower's consideration of centralised churches as simple circles or centres, Robin Evans identifies multiple centres along the vertical direction in Sant' Eligio Orefici, (illustration 1.34). Similarly to Frankl who looks at the ways the centres of the ancillary spaces are visited, Evans looks at the ways the vertically arranged centres are experienced by an observer inside the church. He suggests that, from a geometrical point of view, certain centres are strong indicators of centrality. However, from the point of view of the observer they present an ambiguity concerning their location in height as well as their actual presence.

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115 Wittkower's description shifts from mathematics and geometry to music, to architecture, to religion and cosmology hardly developing full descriptions of ideas in each of these areas separately from one another. As Robin Evans suggests Wittkower, in the footsteps of some Renaissance theorists, used geometry and proportion to stitch universe, music and architecture into a coherent system. Robin Evans, 'The Projective Cast, Architecture and its Three Geometries', The MIT Press, 1995, p. 243.

116 This observation should not be seen as an implied criticism of the preoccupation of the Renaissance theories with proportions. The notion of proportions however crucial or not in architecture falls outside the subject undertaken by this research. Whenever references to proportions are made they serve as vehicles to examine how architecture is approached by various theories and not as objectives.

117 Paul Frankl, 'Principles of Architectural History, The four Phases of Architectural style, 1420-1900', The MIT Press, 1986, p. 6, 8.

118 Paul Frankl, ibid., p. 5, 17.

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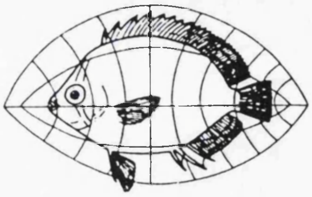

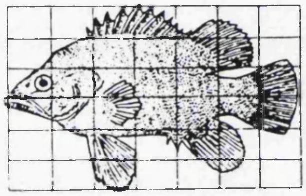

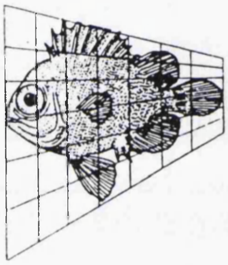

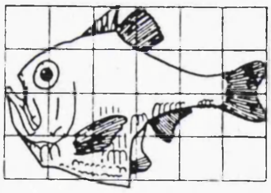

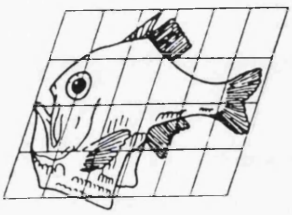

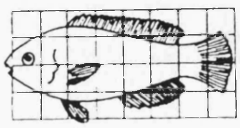

Thus, Wittkower's simple shapes reduce a complex geometrical system to a single element. At the level of the observer's experience this system deals with higher levels of complexity like the relationship of these forms to a form of spatial movement as well as to a form of visual appearance[119].

In his review of Renaissance theories of cosmic order, Evans suggests that the picture they had is neither certain nor coherent. The celestial models developed into highly complicated systems attempting to save the circle because of an 'intellectual and aesthetic prejudice' for this shape. 'Neither geometry nor cosmology, nor theology could, in the event, turn ideal forms and relations into plausible models of reality without embarrassing contradiction'[120]. Evans concludes that the unity of the architectural forms of the period did not mirror philosophical unity but substituted the absence of unity in ideas about the cosmos.

Thus, Wittkower's view of the symbolic powers of pure forms seems a simplification of cosmological ideas as much as his view of architecture is a simplification of form. As both Evans and Hillier suggest it is rather the mode of operation of form that can allow a description of meaning rather than a description of meaning itself.

The mathematical and geometrical unity pervading all levels of theories about nature and man made structures lost its significance in the seventeenth and the eighteenth centuries. However, after the middle of the nineteenth century an adaptation of mathematical patterns of growth of natural phenomena in art and architecture emerged again. Biological studies brought together by D'Arcy Thompson[121] gave mathematical description to regular natural forms, (illustration 1.35). The golden section and the Fibonacci series resulting in spirals of the molluscan shell, and the rotational symmetries of snow flakes and crystals became constant and recurring themes primarily found in the ideas of Frank Lloyd Wright, Louis Sullivan and Le Corbusier.

The theories of the organic and biologic analogy often lead to naive parallels like the ones drawn by Vasari[122] between the facade of buildings and the human face where door and windows were thought as equivalent to mouth and eyes[123]. It is beyond the scope of this research to attempt an extensive exploration of these theories. However, the short description of them shows the persistent enthusiasm with which architectural discourse approached mathematical and numerical order. It also shows that the

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119 It is not suggested that Wittkower thinks of these plans as simple forms but that he describes them in a simplistic way. Although he observes composite plans instead of simple shapes he reduces them into the notions of circle and centre .

120 Robin Evans, Ibid., p. 43.

121 D'Arcy Thompson, 'On Growth and Form', Cambridge University Press, 1969.

122 'Vasari on Technique', Trans.. L. S. Maclehose, ed. G. Baldwin Brown, London and New York, 1907, p. 96, 97.

123 Philip Steadman, 'The Evolution of Designs', Cambridge University Press, 1979, p. 17.

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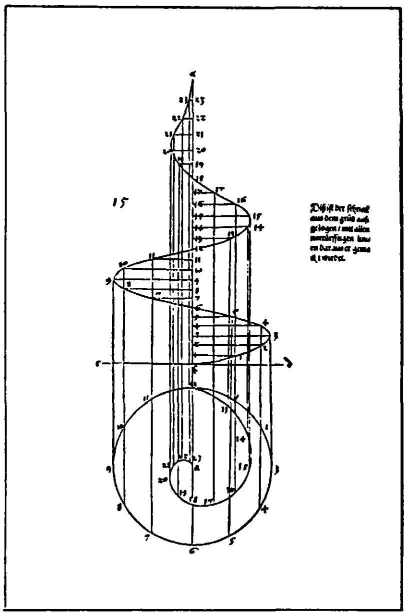

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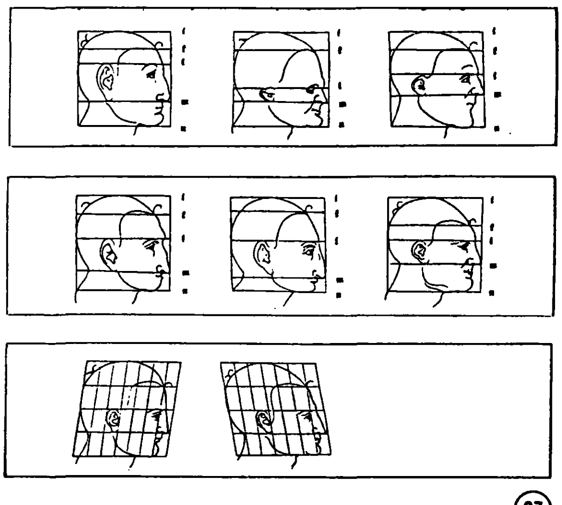

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ideas of harmony, unity and wholeness, identified in the discussion of Botta and Le Corbusier descend from the classical theories of form.

Besides, in spite of their naive analogies the classical theories of form saw that geometrical order is a matter of a complex system of relations and not a matter of a single geometrical element. They also saw that harmony and beauty justified the need for a consistent theory founded on numerical and geometrical reasoning. Thus, they intended to eliminate any belief that the forms of buildings are not bound to any rules, being a matter of individual taste. The following section will examine the reactions to these ideas emerging through theories of sensory observation.

- **THEORIES OF SENSORY EXPERIENCE - Intelligibility founded on collected observation**

Theories of proportion for Erwin Panofsky reach their climax and their decline with Durer who studying the proportional relations of perspective diminution to measure ugliness took proportion beyond its 'artistic usefulness'[124], (illustration 1.37). Durer also applied perspective transformations in architecture by his studies of staircases and columns[125], (illustration 1.36). Thus, the study of perspective gradually transposed a discussion of how harmonic relations appear to an observer in art to a discussion of whether the eye can capture objective relations in a building. Both Panofsky and Wittkower suggest that artistic creation turned from an objective to a subjective way of looking at reality[126].

The problem of the relationship between the world of objective properties and the world of their optical appearance was raised also by Francois Blondel in his discussion of perspective distortions when buildings are viewed from particular locations[127]. In an effort to maintain the Renaissance tradition

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124 Erwin Panofsky, 'Meaning in the Visual Arts', Peregrine Books 1970, p. 135.

125 Robin Evans, Ibid., p. 259.

126 Wittkower sees the decline of proportions as a reaction to the Renaissance theories of absolute truth implying that subjectivity was raised for the first time in history. On the other hand, Panofsky suggests that the distinction between harmonious relations of the human body and harmonious relations as appear to the eyes of the beholder have preoccupied art from the time of Classical antiquity. The Greeks and the Renaissance artists were dealing with the aesthetic idea of *symmetria* and its technical application in representation. The former analyses the human body into objective proportions, while the latter studies the proportions as these 'appear' in reality. Thus, Panofsky suggests that it was Renaissance art which prepared the demise of proportions affirming the changing dimensions of the human limbs as these move in space and the 'autonomous visual experience of the artist as well as of the beholder'. This point of view is also sustained by Evans who explains that perspective was about the 'disruption of measured proportions' recording an appearance rather than a reality.

127 Francois Blondel 'Cours d' Architecture', 1675-83, Paris Francois Blondel, 1698, p. 714 ff.

unquestionable Blondel recommended that adjustments should be made so that proportions should appear correct in perspective.

This was systematically refuted by Claude Perrault who suggested that optical corrections were not necessary because the senses cannot be deceived[128]. Perrault, proposed that the eye can measure by comparison and association the distorted relations of the visual world[129].

Intrigued by the different systems of proportions established by various architects and theorists Perrault proposed a distinction between 'positive' and 'customary beauty'. The former derives from formal and material qualities, while the latter from custom and is, thus, arbitrary. Within the first kind of beauty he distinguished between properties 'that are difficult to discern' like proportion properties that are apparent like symmetry[130]. Since proportions are imposed on architecture by man, Perrault thought he could change them or invent others.

Thus, Perrault criticised the conventional ideas about harmonic ratios rather than proportions themselves. Putting the emphasis on the capacity of vision to capture relative systems he attempted to save them through a new system of proportions that could be easily applicable, recognisable and memorable[131].

A number of authors who sustained the importance of objective properties demonstrated also the importance of the visual world. Temanza suggested that proportions should be judged from the angle from which a building is viewed[132]. Guarino Guarini and Milizia denied their significance putting the emphasis on the observations of a viewer. The eye cannot be pleased by proportions because objects are

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128 Claude Perrault 'Ordonnance for the five kinds of Columns after the Method of the Ancients', The Getty Center for the History of Arts and the Humanities, 1993.

129 'It is not necessary to know the size of something absolutely but only to know how to compare it to the size of things next to it. The coachman judges the space between two coaches through which he wants to pass as too small because he compares this space to the size of the coaches on either side. Similarly the eye judges the size of an entablature and knows very well if it too large, even if does not judge very precisely what its actual size is; it is enough to compare this size to that of the other parts of the building', Ibid., p. 162.

130 Perrault's symmetry identifies with bilateral symmetry and not with Vitruvius' notion of *symmetria,* Ibid., p.p. 50-51, .

131 Perrault's method was based on a division of the parts of a building by whole numbers. He divided an average dimension like the diameter of the base of the column shaft or another dimension determined by the average into equal parts. As he suggests, 'In this way the dimension of the Attic base, which is one half of the module, is divided either into three parts to obtain the height of the plinth, into four to obtain that of the large torus, or into six to obtain that of the small one', Ibid., p. 67.

132 Rudolf Wittkower, Ibid., p. 133.

placed at different heights and in different degrees of enclosure[133]. Milizia discussed also aesthetic criteria with an emphasis on the eye of the observer: 'Anything must be sufficiently simple to be taken in by the eye and sufficiently varied to be seen with pleasure'[134]

Hume declaring that 'all probable reasoning is nothing but a species of sensation' shifted the emphasis from objective properties to the experience of the senses. 'Beauty and deformity, more than sweet and bitter, are not qualities in objects but belong entirely to sentiment'[135]. Lord Kames also supported an argument against proportion based on the changes the observer experiences moving in a layout[136].

Wittkower believes that this generation of theorists were unable to understand how a numerical relation amongst building members that were not adjacent to each other could be possibly seen and understood as pleasing. They introduced a subjective approach to proportion, as well as the limitations of human sight, 'an idea utterly foreign to Renaissance theory'[137].

Amongst those that suggest that the abstract rules of proportions and geometry cannot be part of the visual experience of a building is Roger Scruton[138]. Where things are seen from a single point of view, like a facade, Scruton says, geometrical relations can be comprehended clearly. In plans and sections also. In three dimensional space, though, the clear perfection which the cube and the hemisphere of Brunelleschi's Old Sancrist in S. Lorenzo present in drawings, is no longer present. '...for the observer, the square might be only approximate, and the cupola short of a perfect hemisphere'[139]. To deny proportions and their ability to account for visual experience Scruton turns to Guarini's argument: 'what is harmonious from one angle is not necessarily harmonious from another, whereas in music and mathematics harmony is harmony from whatever point of view'[140].

The Renaissance architects, Scruton suggests, were dealing with ideal excellence appealing to the intellect but not to the senses. Thus, they might not have been preoccupied with this problem. At this point Scruton and Wittkower, supporters of conflicting arguments, agree that Renaissance architects did not worry with the characteristics and 'limitations of human sight'.

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133 Ibid., p. 134.

134 E. H. Gombrich, 'The Sense of Order', Phaidon Press, 1992, p. 28.

135 Rudolf Wittkower, Ibid., p. 135.

136 Ibid., p. 136.

137 Ibid., p. 136.

138 Roger Scruton, 'The Aesthetics of Architecture', Methuen & Co 1979.

139 Ibid., p. 64.

140 Ibid., p. 65.

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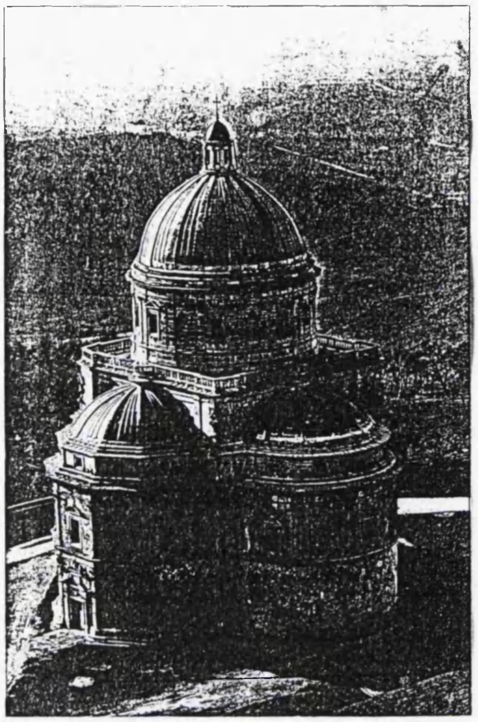

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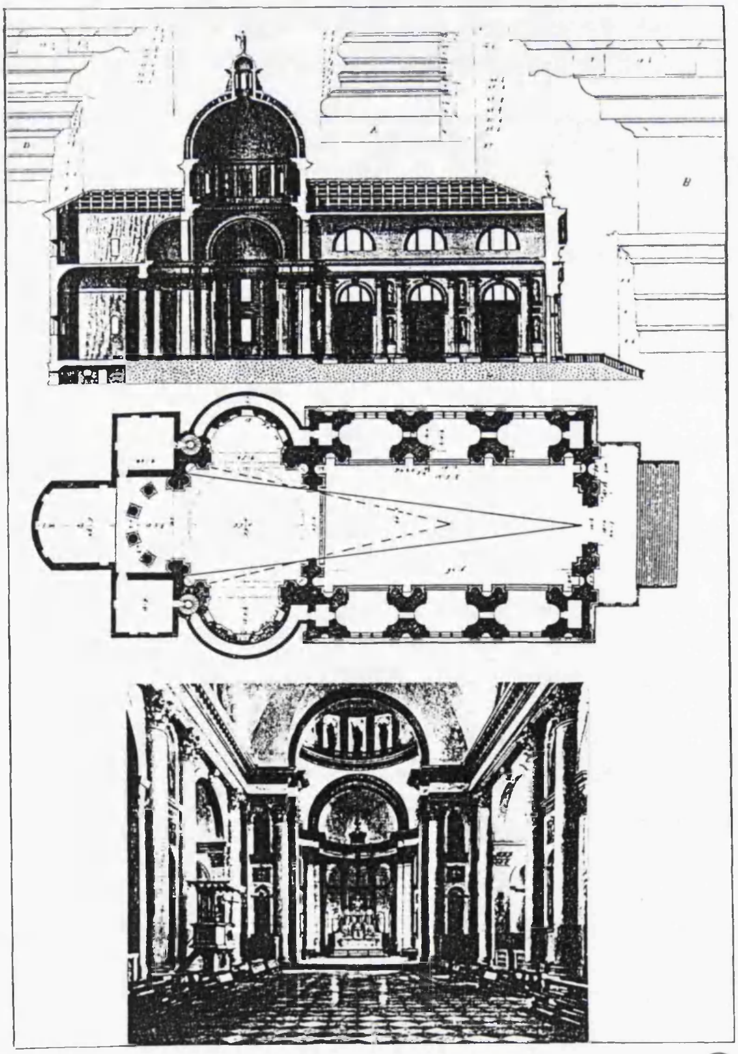

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However, Wittkower offers a contradictory statement. He suggests that Alberti knew about these limitations. He knew that the numerical relations could not be correctly perceived as one walks in a building but he probably thought that they represent an absolute truth independent of subjective perception[141]. In other instances Wittkower suggests that Italian architects strove for the most easily perceptible ratios between the length, height and depth of a building. Thus, Wittkower's opinion on the apparent or hidden role of proportions seems unclear.

In the case of the visual experience of geometrical form he seems less inconsistent. The geometrical planning of the church 'loses nothing of its clarity and effectiveness in the elevations'. Churches like St Maria della Consolazione at Todi seen from the outside 'present the same clarity of the geometrical pattern as in paper', (illustration 1.38). Even when the centralised plan is abandoned, where a central domed structure is combined with a longitudinal nave, corresponding vistas achieve a unification of these spaces, (illustration 1.39). Further, the Palladian villas are 'subconsciously perceptible' to anyone who visits them giving the buildings a 'convincing quality'.

Thus, for Wittkower architectural quality relies on geometrical properties independently of visual experience. At the same time it takes its justification when these properties are visually identifiable. These contradictions reveal an uncertainty regarding where architectural quality lies, as well as whether the divine numbers and shapes present themselves clearly to the eyes of an observer.

- **Abstract versus visual properties**

The discussion of the ways theories approach intelligibility in architecture shows that the relationship between the geometrical properties and the properties observed in spatial experience has attracted a large degree of critical attention. Nevertheless, regardless of the significance of this problem, theories either concentrate on one plane of properties only or choosing one plane they consider the other as its polar opposite.

The Renaissance theories have put the emphasis on the geometrical properties over visual information in space, discovered gradually as one moves in a layout. These properties were defined as a system of constraints from the largest to the smallest part 'so that nothing may be added, taken away, or altered but for the worse'. Stressing the importance of a geometrical unity they focused on a specific kind of geometry only. As such they can explain only buildings that are based on it.

This emphasis on geometrical properties was followed by a deviation towards the opposite extreme. Theories of sensory observation emphasised the importance of spatial experience over the geometrical relations in a building. They stressed that experience is a complex system of sensations unable to access

141 Ibid., p. 18.

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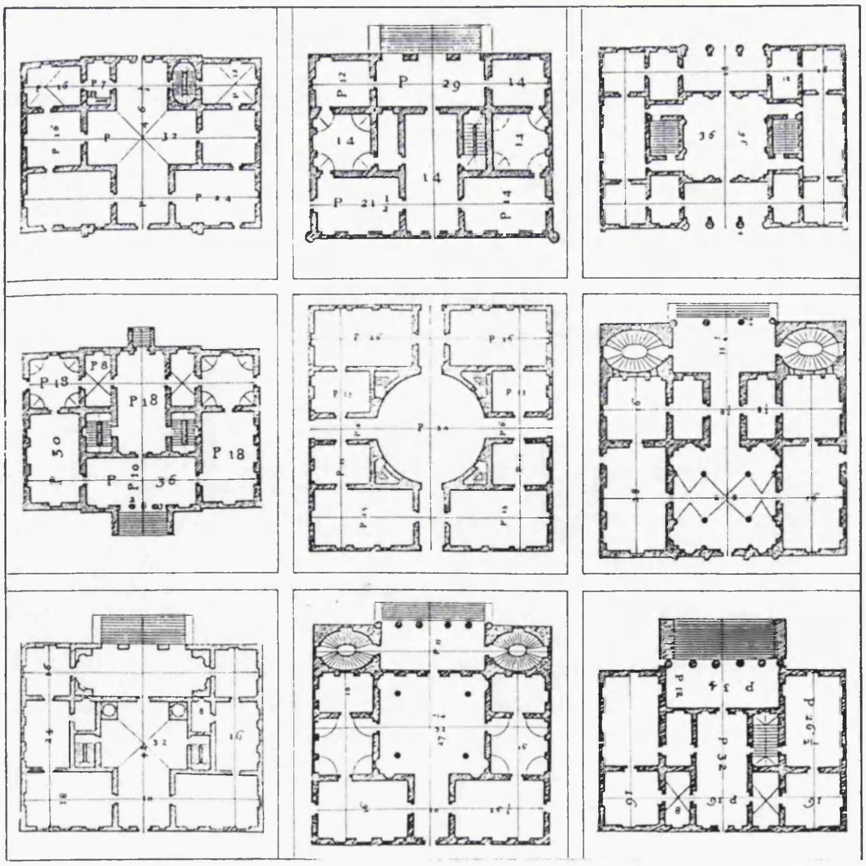

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the abstract geometrical structure. These theories often denied the role of objective laws in architecture suggesting that intelligibility is founded on collected information.

In an attempt to defend the Renaissance theories, Wittkower suggest that they did not stress how geometrical properties register in spatial experience because they were simply preoccupied with abstract relations. In an attempt to attack proportions and geometry, Scruton puts forward the same proposition. However, contrary to Wittkower's and Scruton's opinions the Renaissance architects seemed to have been preoccupied with the presence of proportions and geometry in experience. Alberti writes about 'philosophical' and 'experiential beauty'. The former belongs to the overall order of a building and is a matter of philosophy, the latter to the various parts and is a matter of experience. Experience may grasp relations directly, but where the effort is too great and the order too large, philosophy takes over[142].

Besides, regardless of what Renaissance architects and theorists wrote about this problem, it is not easy to accept that the same artists who dropping a picture plane, the pictorial surface, between the objects of the world and the eye making a discussion of how things 'really are' and how 'they appear' in a picture possible, were not concerned with appearances but only with abstract ideas[143], (illustration 1.40).

The problem of appearances goes back to Euclid and following a long history still preoccupies areas of knowledge related to vision and art[144]. An account of these theories is beyond the scope of this study. However, the preoccupation of the Renaissance artists with them seems enough to take away the prejudice that they were solely preoccupied with abstract ideas.

Examination of a Palladian plan can take this prejudice away not only from Renaissance art but also from architecture. This plan is organised as a series of spatial enclosures the geometrical centres of which are aligned by a system of orthogonal axes, (illustration 1.41). One moves along these axes becoming, thus, aware of their implicit presence in the organisation of the geometrical relations amongst the spatial

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142 Leon Battista Alberti, Ibid., p. 159.

143 The Renaissance artists did not distinguish between geometry and appearances. They distinguished between two kinds of geometry, Euclidean geometry that records the objective structure of the world and perspective geometry that records its appearance. This is the way Lomazzo discusses it: 'Perspective, being subordinate to geometry and as it were the daughter thereof, is a science of visible lines', Robin Evans, Ibid., p. 255.

144 The first model for the description of appearance was provided by Euclid in 'Optica'. The angles and relations of visual lines emitted from the eye and falling to objects of this world determined the appearance of things. The Renaissance artists transferred the visual information from the visual angle to sections through these angles produced by the picture plane. As Margaret Hagen suggests Kepler's discovery of images or pictures on the retina combined Eucleid's visual angles and the painter's explorations opening the way for a theory of vision based on ideas of little pictures in the eye, Margaret Hagen, 'Varieties of Realism', Cambridge University Press, 1986, Appendix D, p. 308.

enclosures. Thus, Palladio was not simply focusing on an abstract geometrical order irrespectively of how it is identifiable. *On the contrary, he seemed to be preoccupied with the ways this order would be accessible by an experiencing subject.*

Allowing visibility and permeability lines that reach the extreme boundaries of the building to pass only through the geometrical centres Renaissance architects *seem to have placed the importance on geometrical properties in gaining intelligibility over the multiple visual fields constructed from spatial points bearing no geometrical significance in the layout. Thus, on the one hand they demonstrated that they were aware of the difference between abstract and visual properties in architecture, while on the other they emphasised the importance of the former over the latter.*

However, regardless of the close relationship between geometrical and visual properties in Renaissance architecture, architectural theory seems to have been considering these properties as polar opposites. This problem generated a dichotomy between what 'is actually there' as a measurable entity and what vision captures as an entity that constantly changes. Its influence is such that architectural discourse was split between architects like Laugier, Schinkel and Mies Van Der Rohe who approached architecture through a rational reasoning and architects like Nash who were concerned with buildings and landscapes as appealing to the senses. The latter gave rise to a picturesque approach to architecture [145].

The distinction between a rational and a sensory approach has been identified by Colin Rowe with a distinction between 'composition' and 'character' in his discussion of the nineteenth century criticism[146]. Composition refers to the academic establishment and resulted in buildings possessing symmetries and axialities. Character refers to the romantic notion of buildings and resulted in free arrangements of masses and materials.

The influence of the abstract-visual division is such that even modern theories interpret the distinction between regularity and irregularity as a distinction between intellectual and sensual form, (Rowe). As it was suggested, this division identifies with contrasts between form and function, form and figure, regular and irregular, order and disorder, classical and picturesque, (Colquhoun, von Moos, Frampton ).

The world seen as divided between the intellect and the senses, between regular and irregular forms was largely promoted in Le Corbusier's writings also[147]. Following Le Corbusier's unresolved dilemmas

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145 Geoffrey Broadbent, 'Design in Architecture, Architecture and the Human Sciences', David Fulton Publishers Ltd, 1988, p. 61.

146 Colin Rowe, 'Character and Composition; or Some Vicissitudes of Architectural Vocabulary in the Nineteenth Century', in the book, 'The Mathematics of the Ideal Villa and Other Essays', The MIT Press, 1984, p. p. 60-81.

147 In his 'Vers Une Architecture' Le Corbusier juxtaposes statements supporting proportions and geometry with statements supporting, function, engineering and sensory pleasure. As Evans suggests Le Corbusier presented

writers like Rowe and Colquhoun see his work as influenced by both approaches, intellectual reasoning founded on classical regularity and sensory pleasure founded on irregularity[148]. Thus, even Rowe whose analysis suggests that geometrical properties are embedded into a building seems to split the world of the geometrical properties and the world of experience apart.

The conflict between abstract properties and sensory observation is a part of a larger philosophical conflict between *rationalism* and *empiricism.* Philosophers assigning importance to the senses are the so called *empiricists.* These are opposed by the *rationalists* who are concerned with what they know to be true through reasoned thinking[149].

It is beyond the aims of this research to explore this problem. However, its embodiment in architectural theory shows that it has created a profound uncertainty regarding the ways geometry relates to the appearance of things in spatial experience. This uncertainty has often generated the question : *Do geometrical properties account for visual experience being routed into the architectural object or do they play no role at all and are simply forced in place by the mind, which knows what it is looking for and thus, recognises them?*

- **THEORIES OF THE RELATION BETWEEN ABSTRACT AND VISUAL PROPERTIES - Two kinds of intelligibility**

In part one it was suggested that certain authors looking at how geometry is manifested in buildings distinguish between apparent and hidden geometrical properties. Rowe recognises the presence of the geometrical grid in the facade of Villa Stein. Von Moos says that it remains hidden behind the irregular surface. Baker proposes that it is partly hidden, partly asserted by individual elements. In the plan of Malcontenta, Rowe suggests, the grid is apparent, while in the plan of Stein it is not.

On the other hand, Zardini and Nicolin suggest that the symmetrical organisation of Botta's houses is expressed in the facades, plans and interior space. Trevisiol looking at Botta's plans reads the geometry of the volume as a whole. Arnheim cannot grasp the geometrical schema of Le Corbusier's Carpenter's Centre even by looking at the plan. Only through a combination of plans is he able to understand the main geometrical idea. Thus, opinions about the apparent or hidden role of geometry seem divided.

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the world as 'shaking in front of exaggerated divisions' so that he could 'fuel his desire to be healer of the wound', Robin Evans, Ibid., p. 276.

148 Rowe observed that in villa Stein the regular structural grid leaves the intellect satisfied, while the irregular plan leaves the senses perplexed. In Rowe's words: 'Conceptually all is clear; but, sensually, all is deeply perplexing', Ibid. p. 12.

149 Geoffrey Broadbent, Ibid., p.p. 59-61.

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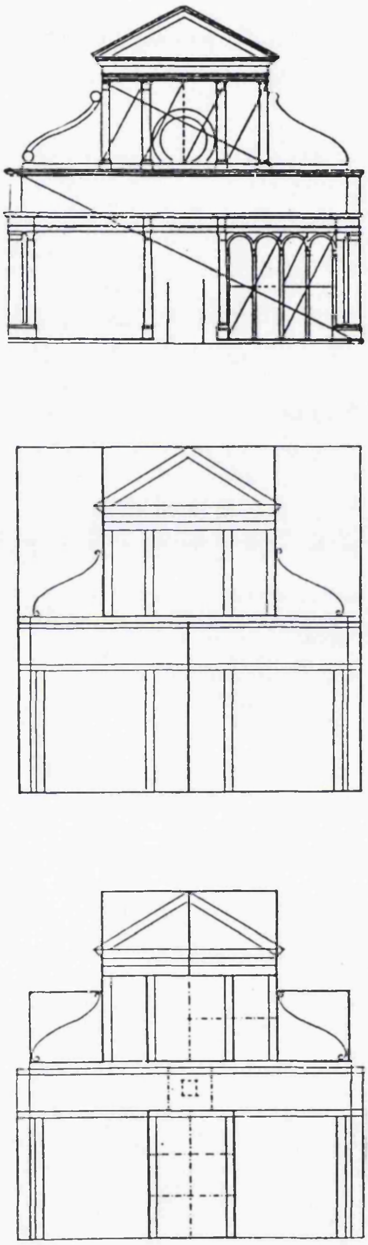

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A similar distinction between apparent and hidden properties is proposed by Evans. Evans suggests that the architecture of the Renaissance did not try to show proportions in things but tried to bury them in things so that a mental effort is required for their discovery. Evans uses the example of Alberti's facades where proportions are expressed by auxiliary lines that are not present in reality[150], (illustration 1.42).

On the other hand, Heinrich Wofflin suggests that the complication of contours is what buried proportions behind the building's corporeality[151]. Paul Frankl supports the same argument saying that Renaissance architecture characterised by clear contours and clear geometrical relations amongst the components enabled the proportional patterns to be discernible[152].

Wofflin and Frankl seem to sustain a useful argument. *The simpler and clearer a pattern is, the easier its properties are grasped.* It is beyond the interest of this research to explore how proportions are discernible. However Wofflin's and Frankl's ideas might be useful for the role of geometry in visual experience.

Heinrich Wofflin concerned with the distinction between things as 'they are' and things as 'they appear' describes the ways formal properties of Renaissance and Baroque[153] architecture register into perception[154]. In the former every object has a clear contour that emphasises the lucidity of a simple pattern. In the latter contours are blurred emphasising the sensation of a moving mass[155]. Baroque architecture puts an emphasis on *corporeality* creating a sensation of 'movement' and 'direction'. Renaissance architecture emphasises the static character of *structural skeleton* creating a sensation of *permanence.*

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150 Evans seems right saying that auxiliary lines are absent in these facades. However, these lines might be useful for an architect wanting to check proportional relations only in drawing. In reality, as Perrault suggests, an observer checks proportions by comparing relative sizes rather than by imagining diagonal auxiliary lines. Thus, Evan's suggestion does not clarify anything about the presence or absence of proportions in observation.

151 Heinrich Wofflin, 'Renaissance and Baroque', Cornel University Press, 1992, p. 68.

152 Paul Frankl, Ibid., p. 112.

153 Wofflin calls Baroque those architectural developments that are usually thought as marking Mannerist period.

154 Heinrich Wofflin, Ibid.

155 The change from the one system to the other is marked by a 'process of unification' applied from the plan and the facade to the smallest detail of a building. Thus, the articulated centralised plan of the Renaissance was replaced by the single unified space of Baroque architecture. Facades composed of clearly identifiable storeys were replaced by a single uniform body. Finally, the individual forms with sharp edges were replaced by rounded ones that were multiplied, and overlaid to enhance their imprisonment in mass as well as the overall effect of the whole, ibid.

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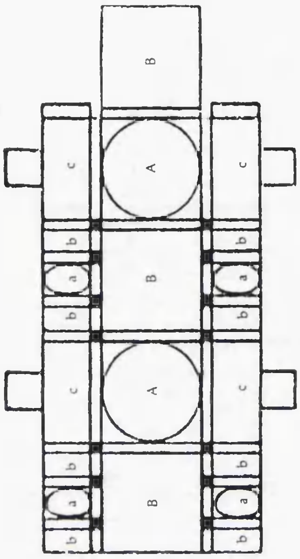

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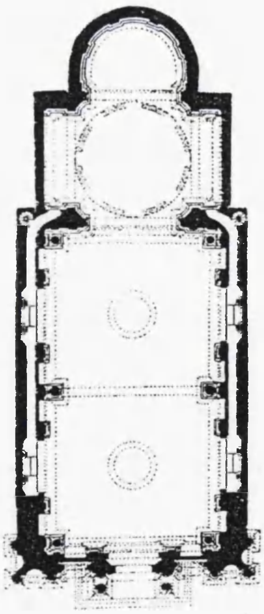

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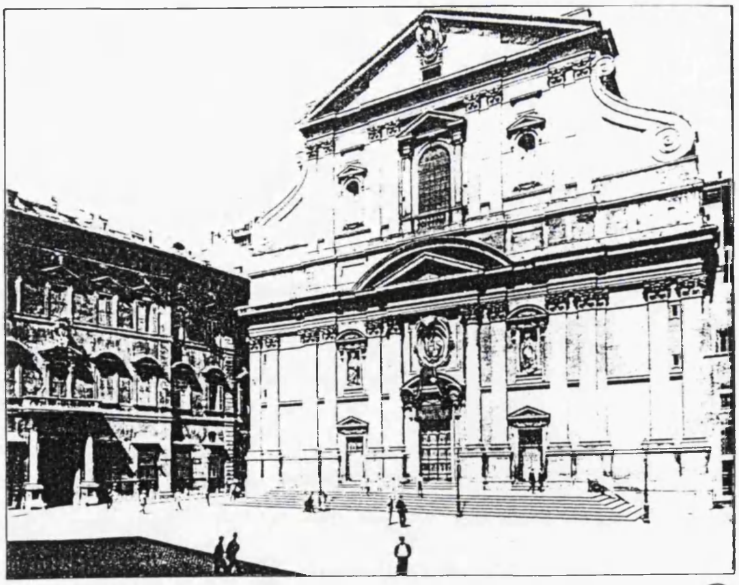

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Thus, Renaissance buildings characterised by clearly identifiable components register immediately upon perception. On the other hand, Baroque buildings characterised by unclear components that disappear into a large mass, are not taken at a glance. In this way, they stimulate an observer to imagine what is not 'seen'[156].

Similar observations are put forward by Paul Frankl. In a study of the stylistic changes from the fifteenth to the end of the nineteenth century Frankl distinguishes between *spatial, corporeal* and *visible* form[157]. *Spatial form* accounts for the arrangement of space as a geometrical pattern and as a pattern of movement. *Corporeal form* accounts for the geometrical arrangement of surface and mass along the vertical direction. *Visible form* or *architectural image,* as Frankl calls it, accounts for the *mental image* of the building constructed as one walks through its space.

In the first phase spatial form is characterised by 'spatial addition' where a series of clearly identified spatial entities are rhythmically arranged next to each other, (illustration 1.43). Movement progresses along the centres of these shapes in a planned path that connects each centre to the central space. Corporeal form is characterised by clear isolation of rhythmically spaced components from the individual stories to the smallest detail of the facades, (illustration 1.44). The clear contours result in the formation of a clear skeleton that can be sensed everywhere like a 'firm articulated structure of bones and muscles'.

In the second phase spatial form is characterised by 'spatial division'. It no longer consists of complete and isolated units but of overlapping fractions of a pre-existent whole, (illustration 1.45). Movement instead of progressing along individual centres flows and floods space. Corporeal form consists of concealed members that look incomplete. The skeleton disappears behind the skin of the facade which is fused into a single body like the interior space, (illustration 1.46).

Looking at visible form Frankl suggests that in the first phase images produced from any point are subordinated to 'objective clarity'. Although the architectural image is produced as one walks through the building, in this phase it is obtained by standing at very few points. 'There is no temptation for us to walk around the building because we realise at once that it can offer us no surprises'[158]. Frontal views compel one to see in terms of orthogonal parallel projection. Oblique views are overcome because temporary perspectives enable imagination to complete the architectural image. This image is dependent

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156 However, as Wofflin says, even when imagination is activated 'The principles of the design are difficult to recognise and in the face of this intelligibility the eye remains perpetually in a state of unrest', Ibid., p. 64.

157 Frankl identifies four stylistic phases focusing mainly on the first two, (1420 - 1550, 1550 - 1700). Paul Frankl, Ibid.

158 Ibid., p. 144.

upon corporeal form in a way that is 'genetically secondary'.'...optical appearance...is always primary with regard to effect, but in the genetic sense it can be also secondary'[159].

In the second phase the blurred contours of individual members create changing images, none of which is complete. Diagonal views are favoured over frontal ones, none of which can help one to deduce the others. The total conception of the optical image is, thus, multiplex.

'We know that as a whole this image is caused by something invariable, but this invariable is only of scientific interest...artistically only the impression of change has value....We immediately survey the situation and perceive that this first image is unstable, momentary, accidental. From a second and third viewpoint the building becomes something we had not expected ...The architectural image - our conception of the total optical appearance of the building - certainly remains a unit, but it now contains a multiplicity of partial images...We know what lies before us is a stable entity, but we see it not as a unique phenomenon but as a recurring one[160].

Frankl's spatial and corporeal form seem to refer to the organisation of a building at the synchronous plane of geometry. Visible form, the 'conception of the total optical appearance', refers to the geometrical organisation as grasped by an observer in the plane of actual space.

Geometry is 'genetically' important and is considered as 'invariable'. Visible form is aesthetically important and is either subordinate or differentiated from geometry. In the first case geometry is exposed as a constant entity. In the second one it is buried behind images that are constantly transformed. Thus, Frankl suggests that in certain layouts there is a difference between 'invariable' geometrical properties and visual experience. However, in his attempt to account for intelligibility he does not credit the one over the other. On the contrary, he identifies different ways in which this invariable is accessed.

Frankl's and Wofflin's distinction between a system that exposes and a system that buries the geometrical skeleton seems analogous to Rowe's distinction between the apparent grid of the Palladian plan and the hidden grid of Stein's plan. Unlike Rowe, though, whose contradictions lead to the distinction between an intellectual-abstract and a sensual-physical experience, Frankl and Wofflin do not see a polarity between geometrical and visual properties. *They only distinguish between geometrical properties that are easy to discern and those that are not.*

In spatial and corporeal form different geometrical properties of contour reveal or conceal the geometrical skeleton of the work. *What follows from this observation is that the ability to 'see' geometry with or without mental effort is determined by the type of geometry used.*

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159 Ibid., p. 146.

160 Ibid., p. 151.

In visible form identical images constructed from different view points, frontality and simplicity of the total image offer an easy access to geometry. On the other hand, contrasting images and lack of clarity, of frontality and simplicity of the total image deny easy access to geometrical order.

However, visible form is defined as a series of images the properties of which are not sufficiently described apart from certain vague characteristics like frontality, congruence and simplicity. Thus, lacking an analysis of the properties of visible form Frankl does not clarify what enables the observer to understand geometry while moving in space. Thus, although he acknowledges the importance of both kinds of properties, he does not offer an analytic description of the ways they relate together.

- **Incorporeal versus corporeal - Geometry implanted versus geometry embedded**

Wofflin and Frankl move away from a polarity between abstract-geometrical and visual-spatial properties turning their attention towards two kinds of intelligibility. They show that geometrical properties form a constant of objective significance that is either exposed, playing a primary role in the appreciation of a building, or is hidden being aesthetically secondary. Exposure raises geometry to the level of visual properties through geometrical simplicity and clear definition of geometrical elements by a simple contour. The absence of these characteristics buries geometry behind the corporeal surfaces of buildings. When geometry is apparent a building can be understood from few vantage points as imagination completes the missing views. When it is hidden multiple view points have to be tried that never provide a single mental image about the building as a whole.

However, although the geometrical skeleton is exposed through a clear physical definition, Frankl suggests that certain incorporeal elements also become discernible playing an important role in experience. The centres of the additive series or the centres in the Palladian layout examined before are examples of such elements. Evans also suggests that Renaissance architecture presents the paradox of a materialised periphery in the form of the corporeal boundary and of an empty, immaterial centre[161]. For Frankl these immaterial centres encourage an observer to stand on them and complete with his imagination the perspectives of the remaining positions he has not visited. Similarly to visible form a large extent of which is completed by imagination, these elements seem to emerge through the imagination of the observer.

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161 According to Evans the invisibility of this centre was replaced by an iconography that filled the periphery of the spherical body as well as by a multiplication of centres along the vertical direction. Euclidean geometry, as Evans says, is full of elements that like the circle define elements 'to which themselves do not belong'. Nevertheless, these elements occupy an important place in architectural discourse as well as in the ways geometry renders itself intelligible in space, Robin Evans, Ibid. p. 40.

With these observations the paradox of a geometry that is embedded and geometry that is implanted by a perceiving mind seems to arise again. *If geometry becomes apparent by clear definition of contour how do elements that are not physically present, like the absent centres or views formed from positions that are not visited, become apparent? Do these elements really exist or they are forced in place by a perceiving mind?*

Looking at the Palladian layout, it turns out that the geometrical centres of the spatial enclosures are located on the geometrical axes that structure the patterns of movement and of visual fields in space, (illustration 1.41, page 68). *If visual properties, or properties of visible-optical form, as Frankl calls them, are about how one moves and what one sees in actual space, then it could be argued that in this layout the structure at the sequential plane of actual space corresponds to the structure at the synchronous plane of geometry.*

An observer looking for those positions that offer maximum visual information moves to the geometrical centres of the rooms. Thus, the visual properties embedded in the geometrical properties compel the viewer to look for locations that offer access to geometry. This is what Frankl seems to imply, saying that movement along spatial centres encourages frontal views creating an intelligibility founded on orthogonal projection. It is this correspondence that creates an understanding of visible form from view points in the first phase. Capturing a geometry that reflects the visual patterns in space, one can rely on it and infer views from non visited positions.

Thus, the immaterial centres are elements in a pattern at the synchronous plane of geometry as well as elements in a pattern at the sequential plane of spatial experience. *Although abstract and incorporeal they are also actual structuring experience in space.* A similar proposition is put forward by Evans. In architectural design geometrical elements are as abstract as real. They are the media conveying 'shape from one state to the other'.

'In a universe constructed after the fashion of Western metaphysics, with matter and spirit opposed, geometric forms move easily across the border between the visible and the invisible, the corporeal and the incorporeal, the absolute and the contingent, the ideal and the real'[162].

What follows from these observations is that *geometry is not an idealised world of abstract properties inaccessible to the senses. It is embedded in the world of reality as observed by the eyes of the experiencing subject.* If geometry is not easily accessible, like in the second phase of Frankl or in Baroque architecture of Wofflin, it is not because it has no relevance to experience but because is a

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162 In the anthropocentricity of Renaissance architecture man was thought as being 'in the middle of a nexus of communications between extreme states' and was, thus, 'dependent on the flow of the traffic through the web'. Robin Evans, Ibid., p. 38.

particular kind of geometry that is difficult to discern. If it is accessible it is because it is simple, expressed by corporeality and embedded into the visual patterns of space.

Evans suggests that in the 'web of communication' between abstract and real, man assumes the role of both the 'spider' and the 'fly'. Stripping architecture from its corporeal substance, as Ficino suggested, leads one to discover its abstract geometry like a 'fly' captured in this web[163]. On the other hand, man is also the 'spider' capable not only of 'de-materialisation' but also of construction of form.

The problem of whether geometrical order is inherent in the architectural object or implanted by a perceiving mind can be, thus, reformulated. Geometry does not reside either in the object or in the mind. It is the medium that occupies both extremes. The fact that man constructs architectural forms plays an important role in the ways he understands them.

Bill Hillier and Adrian Leaman also suggest that the division between the material world and the world the mind occupies removes the structures of what Popper defined as 'World Three'[164]. It is through this world that the human creations acquire their significance and become understood[165].

It could be argued, then, that this is what the absent centre in Renaissance architecture expresses. If as these authors suggest man is in the middle of 'a nexus of communications between extreme states' *this centre is filled with his bodily presence to realise his role in this communication between the geometrical and the visual, the incorporeal and the real.*

Thus, in spite of their simplistic connections between the microcosm and the macrocosm, the Renaissance theories saw that intelligibility emerges from the numerical and geometrical constraints imposed on the relationships amongst the parts and amongst the parts and the whole. This seems to explain the preference they showed for the notion of unity, balance and wholeness as capturing these constraints applied from the largest to the smallest part 'so that nothing may be added, taken away, or altered but for the worse'. The way they expressed that in space was through the primacy of the objective

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163 'Ficino in one of his numerous demonstrations of the incorporeal nature of beauty (involving colour, light and number as well as shape and order), asked his reader to envisage a building, and rather to "try for a moment to abstract the matter, if you can. Abstract it in your thought. Then abstract the matter from the building and leave the order suspended [as it is]. Nothing will remain of the material body". Alberti gave the same advice. Are we then the spiders or the flies in this web/ While we may follow Ficino's instructions, and dematerialise forms, is it not just miraculous that they can be made by us with a material precision that accommodates the disinterring imagination?', Robin Evans, Ibid., p. 38.

164 'A Pocket Popper', edited by David Miller, Fontana paperbacks 1983, p.p 71-72.

165 Bill Hillier, Adrian Leaman, 'The Man-Environment Paradigm and its Paradoxes', Architectural Design, 8, 1973, p.p. 507-511.

properties over the ephemeral and changing visual information in space, discovered gradually as one moves in a layout.

On the other hand, theories of sensory observation could be seen as expressing an awareness about the complexities of spatial experience. This experience cannot often rely on apparent geometrical properties requiring a process of learning. The way this was expressed in architecture was through an increased complexity of articulation that complicates the access to geometry.

*Thus, the proposition that geometrical structure is embedded in the object of learning which is knowable through successive experience put forward in part one seems to be reaffirmed by an examination of theories in this section. Besides, the hypothesis that geometrical unity determines intelligibility in a way that buildings become easily understood seems also to be reaffirmed. However, further testing of these propositions is attempted in the following sections.*

The questions that arise at this point are:

- *How does the individual dematerialises the object to arrive at its core of objective significance?*
- *How is the apparent correlated with what is not known and requires sequential exploration?*
- *How can a theoretical and analytical framework of the ways these operations take place in space be constructed explaining intelligibility of layouts that are more complex than the one used in illustration 1.41,* (page 68)*?*

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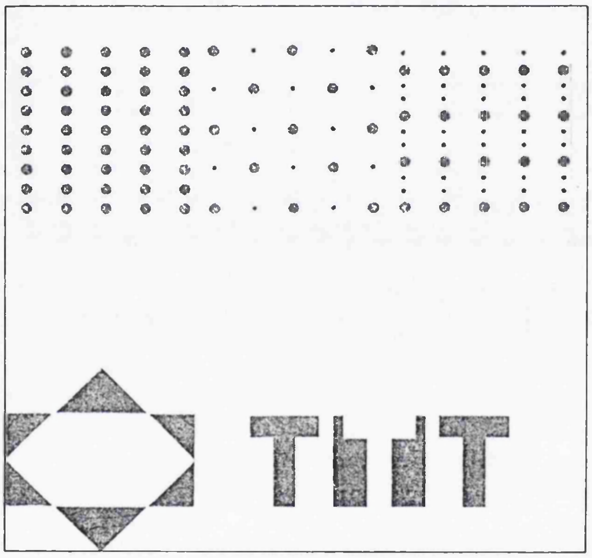


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- **GEOMETRY AS A FACTOR IN PERCEPTION IN ART AND ARCHITECTURE - Intelligibility founded on wholes, breaks and invariants along a transformation.**

The way in which answers can be given to the questions presented above has been considered by a number of theories dealing with the psychology of perception. In this section some of these theories are reviewed with the scope to illuminate how visual properties offer access to geometrical properties. The aim is to identify useful contributions to this problem rather than to provide an extensive exploration of visual perception.

- **PERCEPTION OF PICTORIAL PATTERNS**

- **The Gestalt theory of perception**

Amongst the most influential theories of visual perception is Gestalt psychology. Gestalt psychologists opposed the empirical theories in which 'percepts are the mosaics of visual sensations'[166] with the idea of 'wholeness'. A 'whole' is a simple configuration consisting of straight lines, circles and other elementary geometrical concepts. Rather than being a random selection or association of parts, this configuration is determined by its own laws. Patterns tend to take the 'best form' possible, 'good forms' being simple, regular and symmetrical.

A group of elements is understood according to principles of *simplicity, proximity, area, symmetry, good continuation, closeness and common fate*[167]. Thus, elements entering to the simplest arrangement, (law of simplicity), being close to each other, (law of proximity), continuing a form, (law of good continuation), symmetrically arranged, (law of symmetry), and in uniform orientation to the axes of the available space, (law of common fate), are seen as belonging to a uniform figure[168], (illustration 1.47).

Another important Gestalt law is the figure-ground principle in which boundaries are perceived as belonging to a figure rather than to the ground. This principle is reversible. A figure often assumes the role of ground and vice versa. In these cases perceptual ambiguity is involved in complicating the understanding of a pattern. Various authors from Arnheim to Robert Venturi [169] and William

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166 Nicholas Pastore, 'A Selective History of Theories of Visual Perception, 1650-1950', Oxford University Press, London 1971, p. 272.

167 William Mitchell and Margaret Hagen suggest that although the theoretical basis of Gestalt psychology has been refuted, its laws are still considered as useful instruments in describing the two dimensional appearances of patterns. William Mitchell, Ibid. p. 6, also Margaret Hagen, Ibid., p. 206.

168 Margaret Hagen, ibid., p. 206.

169 Robert Venturi, 'Complexity and Contradiction in Architecture', New York: The Museum of Modern Art, Doubleday & Co., 1966..

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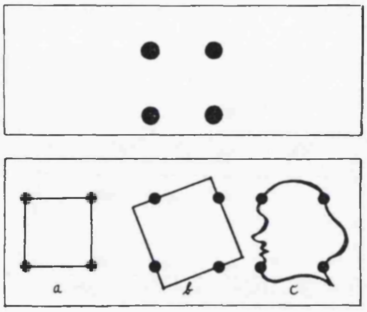


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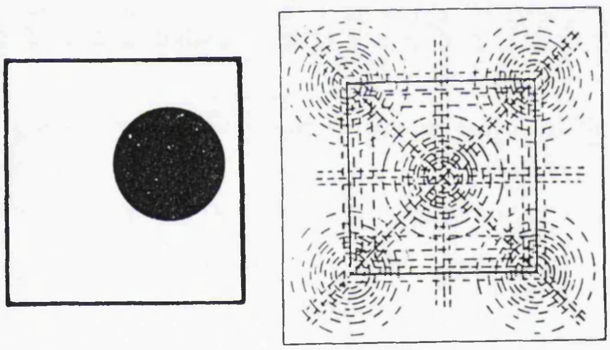

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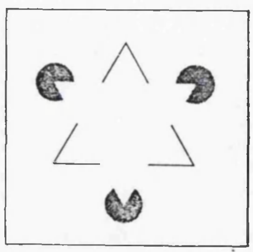

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Mitchell[170] have stressed that in certain cases this ambiguity is an important parameter of the aesthetic pleasure derived from a situation.

According to Rudolf Arnheim 'any stimulus pattern tends to be seen in such a way that the resulting structure is as simple as the given conditions permit'[171]. Thus, a pattern like the one in illustration 1.48 is organised as a square rather than as a diamond or a face, according to the law of simplicity[172]. The consequence of the Gestalt argument is:

'There are then more things in the field of vision than those recorded by the retina of the eye...An incompletely drawn circle looks like a complete circle with a gap. In a picture done in central perspective the vanishing point may be established by the convergent lines even though no actual point of meeting can be seen ...'[173].

In illustration 1.49 what is perceived is not only a square and a circle but also a 'structural skeleton' such as the dashed lines. Besides, when particular boundaries of a figure are omitted it still retains its recognisabilty, (illustration 1.50). The example known as the 'Kanizsa triangle' demonstrates that an incomplete inverted triangle is perceived although its outline is missing.

Cultural knowledge and past experience play an important role in the grasping of the absent structural features in a pattern. Thus, according to Gestalt psychology the parameters involved in pattern recognition are: physical elements recorded on the retina, elements absent but inferred and past knowledge.

- **The Information theory of perception**

This theory studies information as a transmission process[174]. It considers geometrical order as an invariant, a kind of 'redundancy' which the perceptual system uses to access information. Redundancy

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170 William Mitchell, points out that the multiple reversals of figure and ground in the Islamic tile patterns engage expectation and surprise creating fascination, William Mitchell, Ibid., p. 6.

171 Rudolf Arnheim, 'Art and Visual Perception', University of California Press, 1974, p. 53.

172 Wolfgang Koehler in an attempt to explain those forces that lead in the perception of closed and simple shapes suggested that the electrical impulses in the visual cortex of the brain result in ordered distribution of charges that make visible what is not there. Ernst Gombrich suggests that although this explanation is no longer valid for the studies of brain function the range of Gestalt observations are still useful awaiting for new interpretations, Ernst Gombrich, 'The Sense of Order', Phaidon press, 1992, p. 114 - 115.

173 Rudolf Arnheim, ibid., p. 12.

174 Information theory arose in the scientific study of transmission of messages in artificial channels investigating the most economical way of sending and receiving signals to expand to the transmission of

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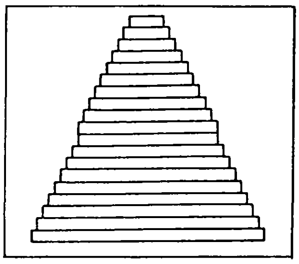

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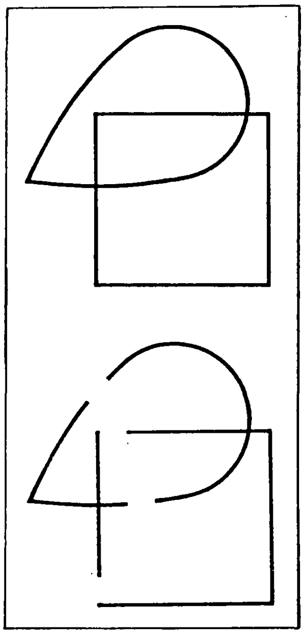

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defines what is superfluous in a message. It guarantees against errors in transmission, permitting the receiver to reconstruct a message even if some of its elements are lacking. The reconstruction of a message is based on his a priori knowledge of the structure of the language[175].

Information value is bound to the *unexpected*, the *unforseeable* or the *original* as a parameter that modifies the receiver's behaviour. Thus, information or originality is a function of the improbability of a received message. As Abraham Moles suggests 'The more structured a message is the more intelligible it is, the more redundant it is and the less originality it has'[176].

Based on Information theory Ernst Gombrich suggests that individuals are equipped with the 'assumption of continuity'. This is a kind of 'forward marching' that they unconsciously perform to understand the world[177]. Continuity is the uninterrupted flow of a pattern, like a continuous shape or a continuous sound. Equipped by the capacity to organise experience by order properties the individual buries continuity of these properties below 'the threshold of attention'.

Thus, continuity is bound to the familiar and the expected. On the other hand, any break in this pattern gives the observer a 'jolt'. In the pyramid of illustration 1.51 the width of the steps in the middle breaking the continuity of progressive diminution attract attention. 'Continuity probing' and 'discontinuity spotting' are both in-built principles enabling one to receive new information based on what is already known and what is unpredictable, on what is probable and what is improbable.

Gombrich suggests that it is not simply the observer's familiarity with geometrical shapes that make him perceive the 'phantom' triangle in illustration 1.50, (page 79). It is continuity assumption that is activated by the breaks in its contour. This assumption fills the missing lines and brings the phantom shape to the level of the observable properties. In illustration 1.52, Gombrich suggests, the familiar shape of the figure 4 is spotted because of the presence of those breaks that distinguish it from the rest of the lines.

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messages in natural channels like vision and hearing. It is a mathematical theory intended to measure the amount of information necessary to reduce the receiver's doubt concerning given alternatives.

175 Abraham Moles, 'Information Theory and Esthetic Perception', University of Illinois Press 1966, p. 55.

176 Moles attempts to synthesise the Gestalt theory of form with the scanning theories of a visual field developed by experimental psychophysiology. He suggests that there is a maximum limit to the flow of information enabling the individual to apprehend forms as elementary stages of intelligibility with the aid of criteria founded on previous knowledge. It this limit is exceeded he either scans the field or loses interest overwhelmed by the originality of the message, Abraham Moles, Ibid., p. 74.

177 Ernst Gombrich, 'The Sense of Order', Phaidon Press, 1992, p. 107 - 108.

'Thus, while the Gestalt approach fastens our perception with order I would draw attention to the reverse, our response to disorder'[178] ... We are always ready to expect and supplement continuities unless the opposite is proved. We behave, in other words, as if we could regard continuities as relatively 'redundant' while breaks will yield the information we seek'[179].

For Gombrich there is an in-built sense of regularity that forces the organism to 'plot the message it receives' against it. The observer rather than responding to stimulus passively, actively seeks order in the environment.

- **FIGURATIVE WHOLES VERSUS BREAKS**

To recapitulate, Arnheim based on the Gestalt theory of perception proposes that the individual's understanding of the objective plane is the simplest and most regular configuration extrapolated from the plane of the observable and aided by previous knowledge of regular phenomena. The geometrical is raised to the level of the apparent by these extrapolations which re-organise explicit and implicit physical events into 'good forms'. From all possible interpretations the ones contributing to the simplest geometry are activated.

On the other hand, Gombrich sees intelligibility as depending on changes occurring in a continuous pattern. Information is a process of active 'hypothesis testing' in which the individual consciously seeks to understand patterns based on breaks of continuity[180]. The perceiving mind attracted by these breaks puts the missing elements in place forced by its in-built sense of order.

Regardless of whether intelligibility relies on wholes or on breaks in a continuous pattern, both Arnheim and Gombrich stress that it relies on relational properties. Thus, they both oppose the empirical approach in which understanding is based on accumulation of fractured visual information. They also seem to explain the ways absent elements are picked up according to their structural role in a configuration. Missing lines, centres and shapes are activated by the laws of simplicity or by the laws of continuity and discontinuity.

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178 Ibid., p. 121.

179 Ibid., p. 122.

180 As Gombrich suggests his approach tries to extend Popper's confirmation and refutation asymmetry into the psychology of perception. 'Popper has convinced me that a theory can never be established with certainty by any number of confirming instances, but it can be knocked out by any single observation which disproves it...We have seen that the simple organism ...learns through collisions, through jolts. We can interpret them as refutations of the hypothesis that it can continue on its path. Exaggerating the point for the sake of emphasis I would identify the built - in hypothesis with the sense of order, the jolt with perception', E. H. Gombrich, Ibid., p. 3.

However, Arnheim's notion of 'wholes' *seems to approach understanding in a pre-scribed figurative fashion.* In illustration 1.47 a square prevails over a face not by the properties of the dots themselves but by the individual's capacity to discern the simplest shape in a field of possible figurative concepts. *Thus, Arnheim's description shifts quickly from the properties of a pattern to the ways it is given shape and form by a perceiving mind.*

Gombrich's shift of emphasis from order to disorder seems to transcend the static nature of Gestalt theory and the a priori configurations the individual already knows. It also seems to overcome the passive role of the observer who simply chooses from a given repertory of possibilities the simplest one. For Gombrich the individual actively seeks to comprehend visual phenomena spotting disorder rather than pre-established configurations which tend to sink below his attention.

However, perception founded on disorder seems tautologous with perception founded on order. This is because the breaks that give the viewer a jolt emerge from the assumption of order against which they are projected as deviations. Although Gombrich opposes the pre-structured nature of the Gestalt whole, he seems to base his 'break spotting' notion on it.

Besides, he also focuses on the ways configurations are perceived by a mind that tries to organise the visual information it receives into a coherent whole. *Therefore, both Arnheim and Gombrich stress the importance of the act of perceiving over the description of a pattern. Therefore, they are not concerned with how perception is possible through a description of properties themselves.*

In this case, as Ernst Cassirer suggests, 'what is sought is confused with what is given, what is to be proved with its premise...The crucial circumstance is rather to be sought in that to which attention is directed, in the goal which thought has in view when it passes over a series of particular contents, and to which it refers these contents as a whole''[181].

These authors see intelligibility either as a matter of laws imposed on the individual or as a matter of mental operations applied over the world of visual phenomena. For the Gestalt theorists structures are wholes that are detached from the individual. For Gombrich they are wholes applied to the world by the individual. It seems that regardless of their emphasis on structures, these authors remove structure from their description implying a separation between the mental and the visual world.

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181 Ernst Cassirer, 'The Philosophy of Symbolic Forms', Volume 3, Yale University Press, 1970, p. 160.

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## PERCEPTION OF SPATIAL PATTERNS

### Perception based on figurative wholes

Arnheim, attempting to explore the visual unity of a building through Gestalt principles, adopts a view similar to Frankl. A work of architecture is understood as a 'mental image' synthesised from partial views that often have nothing to do with the 'objective' shape of the building[182]. Thus, a layout is to be understood as an orderly sequence of spatial experiences. These experiences consist of an 'interplay between the building's timeless existence in space and the time bound event of its being entered, traversed and used by the visitor'[183].

Thus, the intelligibility of space is a process in which a compositional schema is distilled from the many, ever changing and equally valid projective architectural vistas. This process depends on the coherence of the sequence in which things are seen from different view points, on the 'objective' shapes used by the architect and on the simplicity of the schema these shapes produce coming together.

Arnheim reinterprets Frankl's ideas, suggesting that Baroque architecture 'is intended to complicate the viewer's access to the architectural theme and thereby to the fundamental meaning of the building'[184]. This intended complication is analogous to Shakespeare's 'roundabout way of introducing his audience to the core of his plot' [185] and is an essential quality of the work.

Arnheim applies Gestalt laws to the ways perception organises partial views as one moves in space. The laws of simplicity and distance determine the ways the space between objects is perceived. The law of figure and ground determines the ways solids and hollows are understood, (illustration 1.53). Further, the difference between the vertical and the horizontal direction expresses the difference between what one sees in a building and where one can go, i.e. the difference between immediate and sequential visual information.

Thus, Arnheim suggests that the composing architect is primarily preoccupied with the co-ordination of two systems in buildings, the geometrical-compositional schema and the vistas through which this schema is seen. Similarly to the ways the writer of a play arranges in a certain order through his narrative, events that are connected in a different order by the plot, the architect arranges events in space that might be connected in another way in geometry.

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182 Rudolf Arnheim, 'The Dynamics of Architectural Form', University of California Press, 1977, p. 111.

183 Ibid., p. 117.

184 Ibid., p. 120.

185 Ibid., p. 120.

Colin Rowe has also observed a similar phenomenon in Le Corbusier's Villa Stein. The sequence of layered spaces travelling parallel to the facade expressed as a compositional schema from the outside is in contrast with a perpendicular arrangement of space in the interior. For Arnheim this is planned by the architect and is an essential parameter in both the process of composing and decoding a building.

In this respect, Arnheim addresses the same problem with this research, i.e. how the synchronous plane of geometry relates to the sequential plane of spatial experience. He suggests that these two planes are controlled by a composing mind according to certain intentions. The possibility the observer has to capture the geometrical or compositional schema is usually intended, and depends on the kind of geometry the architect chooses.

However, similarly to pictorial patterns, Arnheim approaches space by focusing on perception rather than on a description of its properties. However, even his analysis of perceiving is based on local observations of solids and voids rather than on how perception of the building as a whole is possible. Thus, although he stresses the importance of a whole or a compositional schema he does not describe its properties.

The emphasis Gestalt psychology puts on pictorial, perceptual wholes is also stressed by Peter Eisenman[186]. Similalry to Arnheim, Eisenman suggests that architectural form is understood through movement. Movement brings visual experiences together over a long time span as opposed to pictorial work that requires less time to be grasped.

However, the appreciation of a building, Eisenman says, is conceptual rather than perceptual[187] and develops by reference to 'a formal clarity and unmistakable reference to some well understood archetypal solid'. Only an architectural logic based on this solid can allow a person to keep in his memory everything that he encounters. This archetypal solid refers to generic form used also by Baker. On the other hand, what the person encounters in a building is specific form.

Although Eisenman opposes the Gestalt school's emphasis on perception, he also maintains the importance of wholeness through the notion of the archetypal solid. However, Eisenman's and Baker's proposition as suggested in the previous section, is that understanding of architecture is based on a primary concept from which the form of the building evolves as a transformation. The notion of transformation and its significance in perception is also examined by Margaret Hagen.

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186 Peter Eisenman, Ibid.

187 As it was explained earlier conception refers to the ways an architect has organised his building through a system of rules. Perception refers to the ways these rules look to the eyes of an experiencing subject. This split between conception and perception seems to express a split between the properties of architecture and the interpretation applied to architecture, between object and subject.

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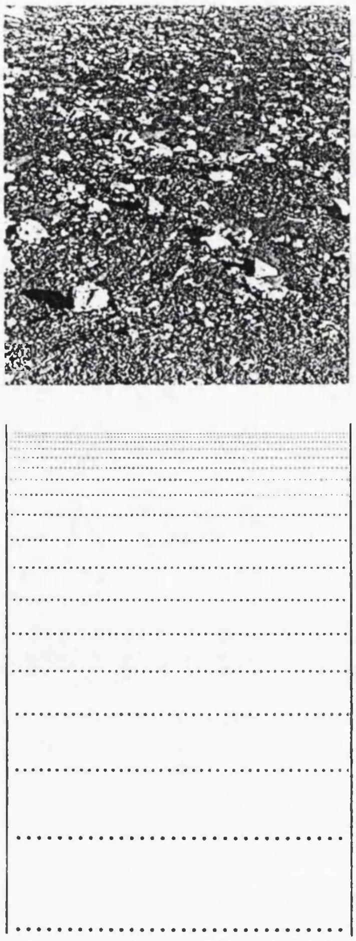

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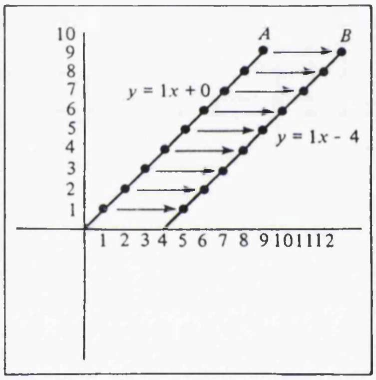


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- **Perception based on invariants along a transformation**

Hagen explores the relationship between the world 'as seen' and the world as 'it is' looking at the geometrical structure of light on the eye as a stimulus for visual perception[188]. She suggests that James Gibson developed a different approach to visual information according to which *it does not depend on pictures or images that are integrated across time but on 'invariant information' that is picked up as the person moves, like size, shape, distance, colour etc.*[189].

Based on this proposition Hagen uses concepts of modern geometry to argue that the transformation in the information provided by pictorial and retinal images is geometrically determined. The understanding of forms is based on the perception of variants and invariants in the transformation of information caused by the observer's movement.

Hagen's ideas are based on 'group theory' which defines geometry as *the study of those properties which remain invariant when the elements of the set are subjected to the transformations of some transformation group*[190]. A geometrical transformation is a mapping of values to another set of values like the mapping of line A onto line B in illustration 1.55. This is called *translation*, leaving the shape and size of a geometrical element invariant, while changing its position. 'Some transformations leave nearly the whole figure in all of its particulars invariant, and some change nearly every property'[191].

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188 Margaret Hagen, Ibid.

189 Hagen starts with Euclid who put visual information to the visual angles formed by the light rays falling in the objects of the world. She suggests that the next significant step was produced by the Renaissance theories of perspective which placed information on the sections through these angles - what is recognised as the perspective image or scene in the picture plane. Kepler discovered that little images are formed on the retina paving the way for a theory of vision based on this idea. Thinkers like Descartes, Berkeley and Helmhottz rejected the resemblance between visual images and the world concentrating on extra visual sources of information., like touch.. Finally, James Gibson argued that perception does not depend on the selection of static single structures but of 'structural invariances across views changing with motion'. An example of properties that stay invariant as a person moves is given by the gradients of texture on a horizontal ground, (illustration 1. 54), Ibid., p.p. 17, 299 - 323.

190 This theory known as the Erlangen programme was developed by Felix Klein in 1872. It lead to a re-formulation of geometry as well as to a unification of the several non Euclidean geometries produced up to the mid nineteenth century, Syed Jan Abas, Amer Shaker Salman, 'Symmetries of Islamic Geometrical Patterns', World Scientific Publishing, 1995, p. 70.

191 Margaret Hagen, Ibid., p. 27.

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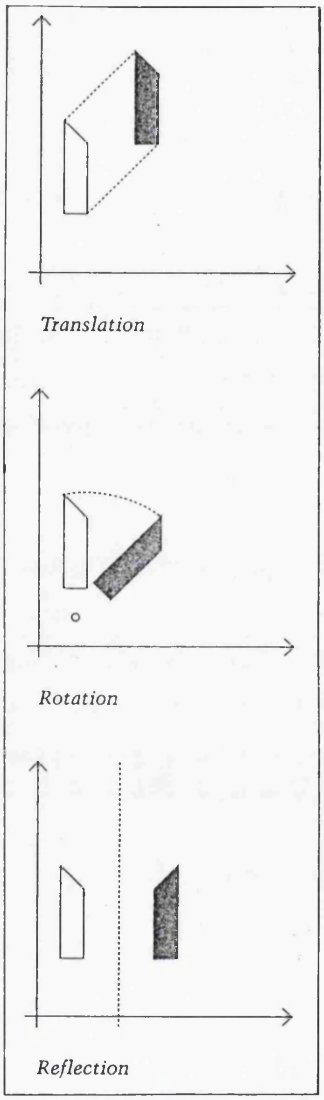


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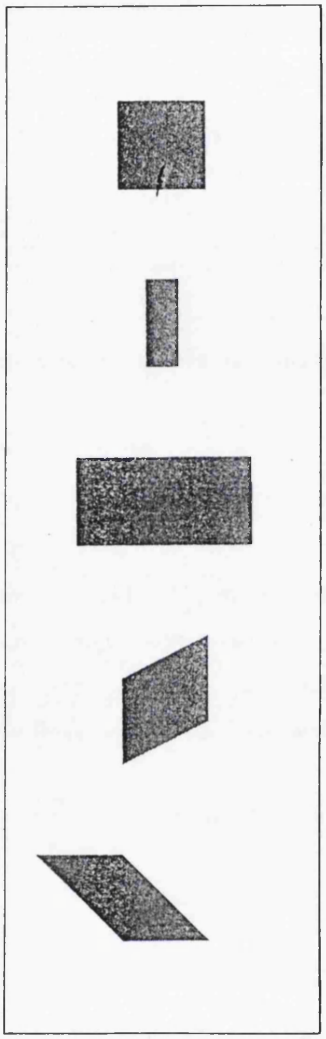

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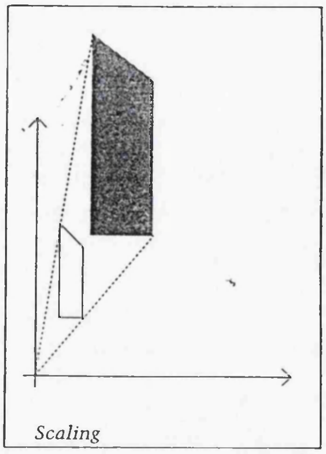


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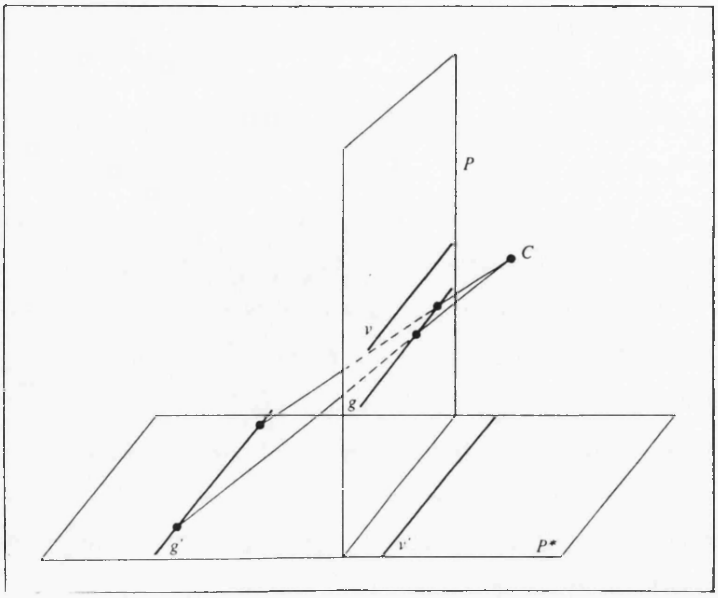


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Group theory defines four categories of geometric transformations according to the properties of figures that they leave invariant, Metric, Similarity, Affine and Projective geometries. These geometries are hierarchically ordered so that from the one to other fewer properties of a figure stay invariant[192].

Hagen suggests that visual information comprises all these geometries. Thus, 'Metric' transformation, (rotations, translations, reflections and glide translations), in perception refers to the congruent images an object offers as an observer moves his eyes from right to left. Certain objects comprise symmetries that offer congruent images when the viewer moves around an object, (illustration 1.60). 'Similarity' transformation, (shrinking or scaling), characterises the images of an object when an observer approaches it at a constant frontal angle, (illustration 1.61). 'Affine' transformation, (stretch and shear), enable one to recognise people through the growth and ageing process, (illustration 1.62). Finally, 'projective' transformation characterises images like those of tabletops as a person moves around them. The invariant of the cross ratio enables the edges of these surfaces to be perceived as straight and the surfaces as flat[193], (illustration 1.63).

Ernst Cassirer discussing Klein's conception of the various geometries also suggests that the formation of the concept of space underlying each of them extends a process that is embedded in empirical space, the space of sensory experience[194]. Cassirer believed that the changing information in this space is guided by a central core in a definite direction. As the eye beyond all differences captures one or another factor as invariant, a unity that 'governs the totality of these relations asserts itself'[195].

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192 In Metric geometry figures are transformed not affecting their metric properties, i.e. size and shape. The transformations of rotation, reflection, translation and glide reflection are metric transformations, (illustration 1.56) In Similarity geometry shape remains the same while size changes. An example of this transformation is 'shrinking' or 'scaling', (illustration 1.57). In Affinity geometry parallelism is preserved whereas shape, angle and size change, like in stretch and shear transformations, (illustration 1.58). Finally, in Projective geometry the properties that stay invariant are very few, like collinearity, the property of being on the same line, the harmonic properties, some topological properties and the cross ratio of points and lines, (illustration 1.59).

193 Hagen argues that visual information based on invariants is simply available to the observer. What determines the actual use of potential information by different observers is not yet known. She also suggests that there are certain limitations to a narrow geometrical analysis of visual information., Margaret Hagen, Ibid., p. 62.

194 Ernst Cassirer, 'The Philosophy of symbolic Forms', Volume 3, Yale University press, 1970, p. 157.

195 However, according to Hagen, Cassirer believed that 'each invariant of perception was in fact a schema toward which particular sense experiences are oriented and with reference to which are interpreted. But he could not see the invariants as informative structures in the light and he did not quite explicitly write that the different levels of the concept of identity were directly available to perception', Margaret Hagen, Ibid., p. 77, 78.

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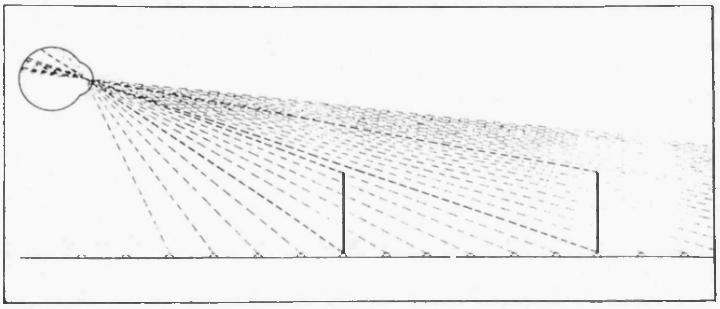

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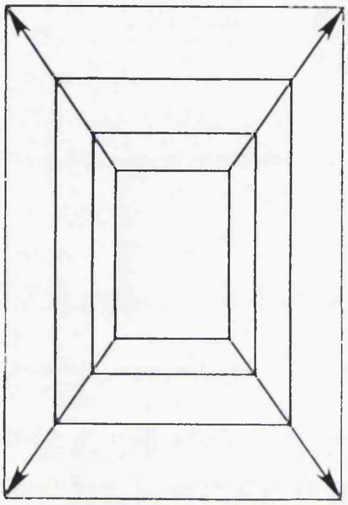

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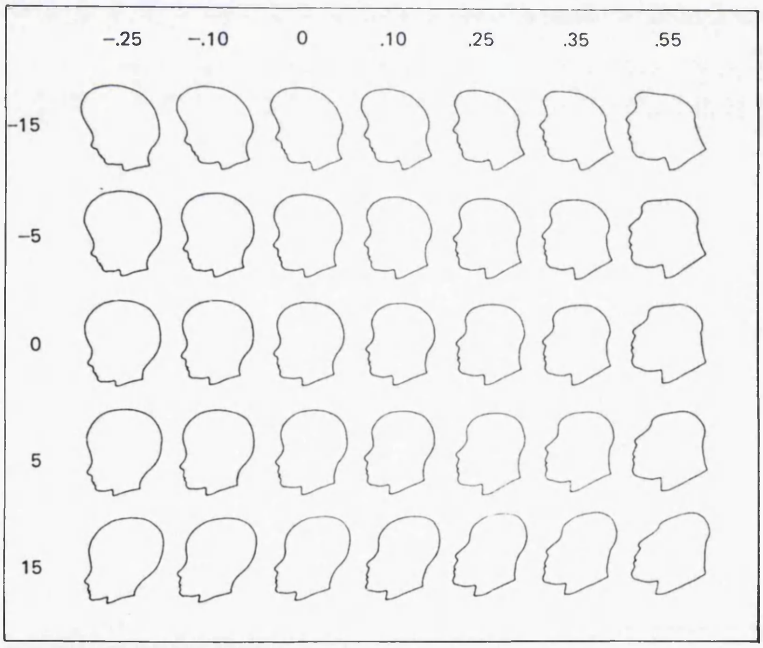


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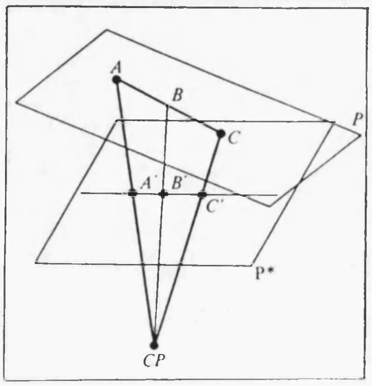


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- **Transformation and its theoretical significance**

The notion of invariants along a transformation as structuring visual information seems to take the problem of the relationship between geometrical and visual properties a step forward. Whereas for Arnheim and Gombrich intelligibility is a matter of how the individual perceives a visual pattern, for Hagen it is a matter of the geometrical parameters in these patterns. Whereas, for the former there is a division between the object of knowledge and perception, for the latter the structure of this object and perception are a single thing.

Whereas for Arnheim and Gombrich intelligibility relies on wholes as fixed entities, for Hagen it is based on characteristics that stay invariant in a dynamic process of transformation. Whereas for these authors wholes are pre-established formations acting a pre-determined role on the designer and the observer, or formations a perceiving mind attributes to an object, for Hagen they emerge from the presence of geometrical structure in visual information. *Thus, intelligibility for Hagen relies on structural parameters inherent in visual patterns rather than on figurative wholes.*

The primacy of transformation over figurative concepts in intelligence is also stressed by Jean Piaget. Piaget suggests that the Erlangen programme established the primacy of transformation over configuration in geometry which was traditionally related to intuition and, thus, to perception.

'Geometry has become clearly operative and has thereby achieved its legitimate place in pure mathematics: not only can each form of space be engendered by the operations which constitute its fundamental 'group' but it is possible to pass from one geometry to the another by means of the rules under which a "sub-group" is subordinated to a group'[196].

Piaget based on group theory distinguished between 'operational' and 'perceptual' or figurative structures. Before proceeding to the ways he sees this difference and the role it plays in intelligence and perception a closer examination of group theory in mathematics is needed.

A group is a set of elements and a rule that combines these elements satisfying four conditions. These are *closure*, *associativity*, *identity* and *reversibility*. Hagen illustrates the concept of the group giving the example of the set of whole positive and negative numbers plus zero with addition as the rule of combination. *Closure* specifies that any product of the combination of two members of the set is also an element of the set, (e.g. 2 + 3 = 5). *Associativity* requires that the result of the combination of any three members is the same however they are grouped, (e.g. (2 + 3) + 5 = 10, 2 + (3 + 5) = 10). *Identity* specifies that the system has a member that combined with any other element in the set leaves this

196 Jean Piaget, 'The Mechanism of Perception', Routledge & Kegan Paull, 1969, p. 357.

element unchanged, (e.g. 3 + 0 = 3). *Reversibility* requires that for every member there is a reciprocal one, such that combining the two gives the identity element, (e.g. 3 + (-3) = 0)[197].

An example of a group in geometry is the circle. The set of elements in the circle are all possible rotations of a radius while the rule of combination is the rotation itself. Hagen suggests that this system is closed because any combination of turns produces a degree of rotation that can be achieved by a single rotation. (45° + 15° = 60°). It has two identity elements the rotations of 0 and 360. It has reversibility because any degree of rotation can be reversed by an opposite turn, (45° + (-45°) = 0°). Finally, it has associativity because 'neither the groupings nor the order of the rotations affect the result'[198].

'Thus, we see that one can transform a member of the class and then recapture identity of the element by reversing the transformation. One can effect a transformation of an element that leaves the identity of the element intact, and the performance of these transformations is entirely within the confines of the system...'

Hagen continues that there is an enormous descriptive economy in the concept of the group. There is no need to enumerate the various members of the set in order to examine their relations.

'The system itself can be considered rather than the individual elements because the performance of the operations within the system does not lead one outside it. Thus, we can consider great classes of things like rotations around the plane or movements through space with elegance and economy'.

Hagen also continues that unlike the whole number system where the elements can be distinguished from the rule of combination *in geometry the transformations are the elements of the group while the rule is the performance of the transformation.* According to group theory shape in Metric geometry is something that remains unchanged under a rule of transformation retaining the fixed distance between any pairs of points. *Thus, it is the outcome of a rule rather than a single entity.* As Ian Stewart and Martin Golubitsky suggest *'transformation is a process that determines the image, and is not the image itself'*[199].

The set of transformations that leaves an object invariant are defined as the 'symmetry group' of this object. Transformations of rotation and reflection in a square, for example, are its symmetry group because after applying these transformations the square remains unchanged, (illustration 1.62). These authors suggest that geometry is a consequence of symmetry. As Klein suggested, geometrical properties are characterised by their invariance under a group of transformations.

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197 Margaret Hagen, Ibid., p. 29

198 Ibid., p. 30.

199 Ian Stewart and Martin Golubitsky, 'Fearful symmetry', Blackwell Publishers, 1992, p. 32.

Group theory also has the means to define symmetry breaking. The authors provide the example of a perfect sphere. Its symmetry group consists of rotations through any angle about any central axis and reflections in any plane through its centre. When the sphere buckles there is a preferred axis and the object is invariant only under rotations through any angle about that axis and reflections in planes that contain this axis. Thus, some of its initial symmetries are removed from consideration.

When symmetry breaks, the symmetry of the resulting state of the system is a subgroup of the symmetry group of the whole system. So symmetry breaking is a change in the symmetry group, from a larger one to a smaller one, from the whole to the part'[200].

As Hermann Weyl says: 'Space itself has the full symmetry corresponding to the group of all possible automorphisms, of all similarities. The symmetry of any figure in space is described by a subgroup of that group'[201].

Thus, during a transformation of an object from one state to another there is a reduction from the set of potential states that retain complete symmetry to states that break and reduce its number of symmetries. As the authors say 'the actual breaks the symmetry of the potential'. The number of symmetries that remain are what stays invariant in the set. Thus, group theory approaches geometrical description through the notion of reduction of symmetries from a highest level to a lower level. Structure is, thus, defined as that which stays invariant during the transformation from a higher level symmetry to a lower level one.

Based on group theory Piaget established the primacy of transformation over figurative concepts. The former characterises 'operational structures', while the latter 'perceptual structures'. Both perceptual and operational structures are laws of equilibrium as Gestalt theory defined them i.e. forms towards which a system tends to organise patterns. However, the former are non additive and irreversible, whereas the latter are additive and reversible. The former are fixed, whereas the latter *describing properties as a set of operational rules that stay invariant from one stage to reproduce the principles of construction.*

Studying the relationship between perception and intelligence, Piaget examines the Gestalt school's consideration of the act of perception as genetically continuous with the act of intelligence. The Gestalt theory seems to imply the notion of relational structure opposing the theories of cumulative sensations or 'atomic association'. However, it provides an explanation to itself and not a descriptive tool neglecting the problem of the ways compositions are achieved. Thus, it seeks the characteristics of totality and not the laws of its construction. This totality reduced the theory into a description of general characteristics

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200 Ibid., p. 52.

201 By automorphisms Weyl means congruent mappings produced when two configurations are carried over into each other, Hermann Weyl, 'Symmetry', Princenton University Press, 1952, p. 45.

into 'a structuralism without genesis'. As such it is the opposite of theories of 'atomic association' which attempt 'a genesis without structure'.

Piaget proposes a substitution of the notion of totality with the notion of relation. 'This in no way excludes the laws of totality which are laws neither of elements nor of relations but of the composition itself of relations'. The notion of relations strives towards the construction of the composition as a whole. As he proposes : 'to know is to construct or to reconstruct the object of knowledge in such a way as to capture the mechanism of its construction'.

'Perception is not the source of knowledge, because knowledge derives from the operative schemes of action as a whole. Perceptions function as connectors which establish constant and local contacts between actions or operations on the one hand, and objects or events on the other. Perceptual messages are transmitted in a figurative form, which is the only form available, and are decoded by being integrated, as far as possible, into the system of transformations'.

Figurative structures, or the Gestalt wholes, for Piaget play an essential role in knowledge but subordinate to operational structures. Once operational structures have been completed, figurative structures correspond only to states between which transformations are effected.

- **Perceptual versus operational structures**

However, Piaget distinguishes between the transmission and the decoding of a message. The former is achieved through figurative form, whereas the latter through the integration of this form into a system of transformation. The former correspond to individual states, whereas the latter to the total set of relations that remain invariant throughout these stages. Thus, although he considers perception and knowledge as interactive processes, the distinction between figurative or perceptual and operational structures seems to encourage the split between perception and construction or perception and conception.

A similar dichotomy was seen by Ernst Cassirer who proposed that the concept of identity in the domain of geometrical concepts permits one to single them out and to grasp structure in perception. As Hagen suggests Cassirer 'denied that perception had direct access to the different levels of the systems of geometry'[202]. Although these authors recognised that transformations are fundamental in the ways the identity of figures is perceived, they seem to have distinguished between the behaviour of perceiving and the abstract description of how perception takes place.

Therefore, from the theories of sensory observation to the theories of perception the examination of the polarities between abstract and real, invisible and visible, structural and figurative, operational and perceptual, seems to come full circle. As it was suggested in the review of Frankl, Evans, Hillier and

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202 Margaret Hagen, Ibid., p. 77.

Leaman *the dichotomy between these concepts could be resolved only if they are seen as parts of the same reality.* Besides, as Stewart and Golubitsky suggest a pattern is understood as a set of properties that remain invariant in a transformation and not as an image.

Hagen suggests that both levels of structure, geometrical and spatial can be studied through the notion of the invariant in a transformation. However, she is concerned with how this notion is employed in representational art and not in architecture. Thus, her suggestion can offer only a theoretical way of approaching this relationship.

Thus, the question that arises at this point is: *Is it possible to construct a common theoretical and analytical framework based on the notion of invariants in a transformation?* Before answering this question further research on how certain theories have approached description of these levels and their relationship from a theoretical and analytical point of view is required.

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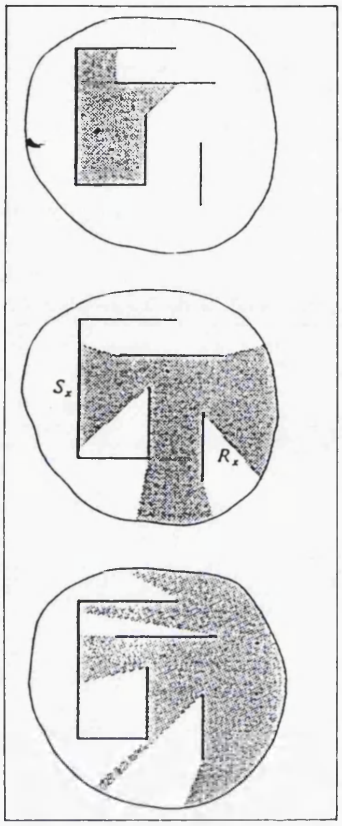


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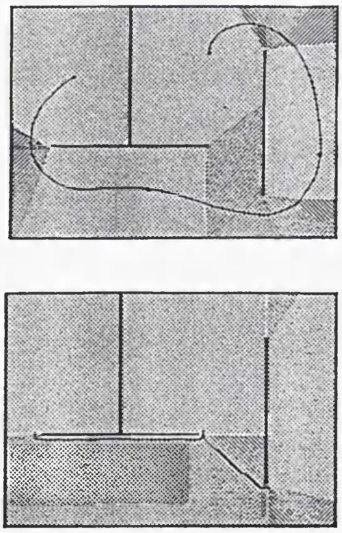

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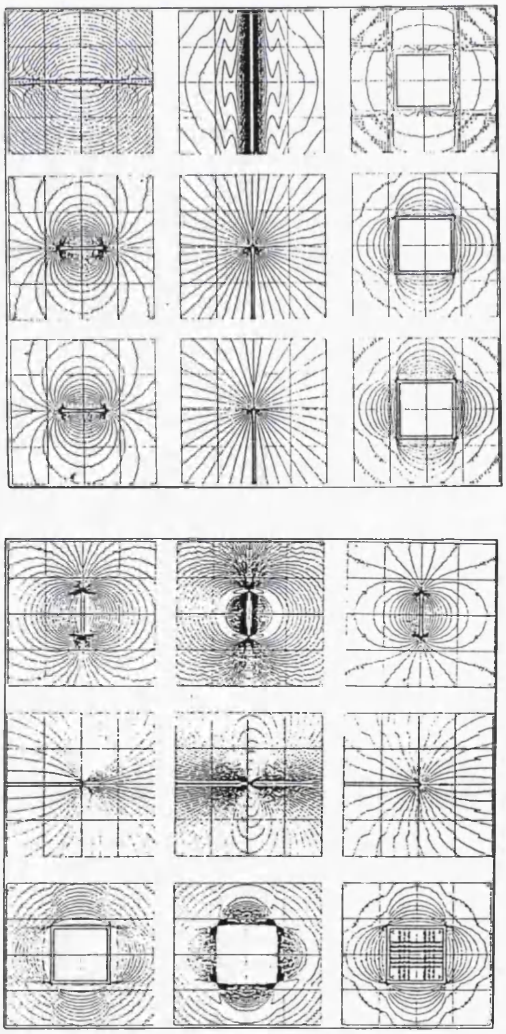

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# PART THREE

## • THEORIES OF RELATIONAL PROPERTIES - Intelligibility founded on relations

A number of approaches have been developed in the recent years which attempt to describe architecture as a rule based system. These approaches differ from the Renaissance theories by stressing not the importance of a mathematical or geometrical order of a specific kind but the importance of relationships. They also differ from the theories of perception by focusing on structural parameters rather than on the act of perception. They can be distinguished into those theories which account for the structure of spatial patterns and those theories which account for the structure of geometry.

## • SPATIAL PATTERNS

### • The notion of isovist and spatial experience

L. H. Benedict based on Gibson's notion of invariance along a transformation attempts to describe spatial experience using the notion of 'location specific pattern of visibility' or 'isovist'[203]. An isovist is the set of all points of a physical environment that are visible from a vantage point representing an observer, (illustration 1.64). 'Describing an environment in terms of the position of its real surfaces ... is entirely equivalent to describing it by the set of all possible isovists corresponding to all points ...'.

Benedict asks how many points are sufficient to see an entire environment and which is the shortest path along these points, (illustration 1.65). He also examines the degree to which one sees sudden or gradual changes moving along a path. These account for changes in properties of an isovist like 'area', 'real surface perimeter', 'occlusivity'[204] etc. that are mapped by gradients on plans, (illustration 1.66).

Benedict's approach is one of the few studies that have attempted to quantify architecture under the dynamic condition of movement. Thus, it offers a useful description and a tool for quantifying architectural experience. However, he sees architecture from the experiential aspect only. Although each isovist captures certain invariant features of a layout, like its surfaces, these are not tested against the total set of geometrical properties present in this layout.

Further, the problem with this approach is that a representation and description of spatial experience would require limitless isovists drawn from the infinite spatial points in a space. Besides, isovists are

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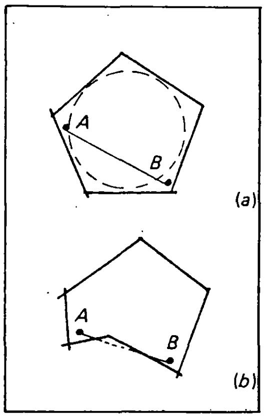
203 L. H. Benedict, 'To Take Hold of Space: Space and Isovist Fields', Environment and Planning B, 1979, volume 6, p. 47-65.

204 Area measures how much space can be seen from a point, perimeter measures how much surface can be seen from this point and so on, Ibid. p. 53.

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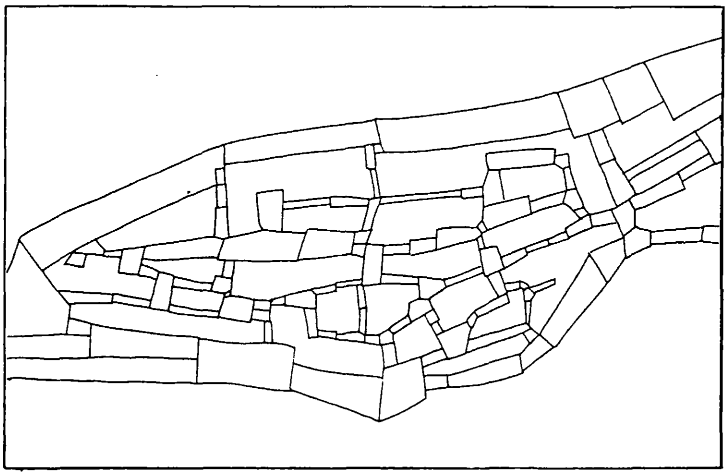

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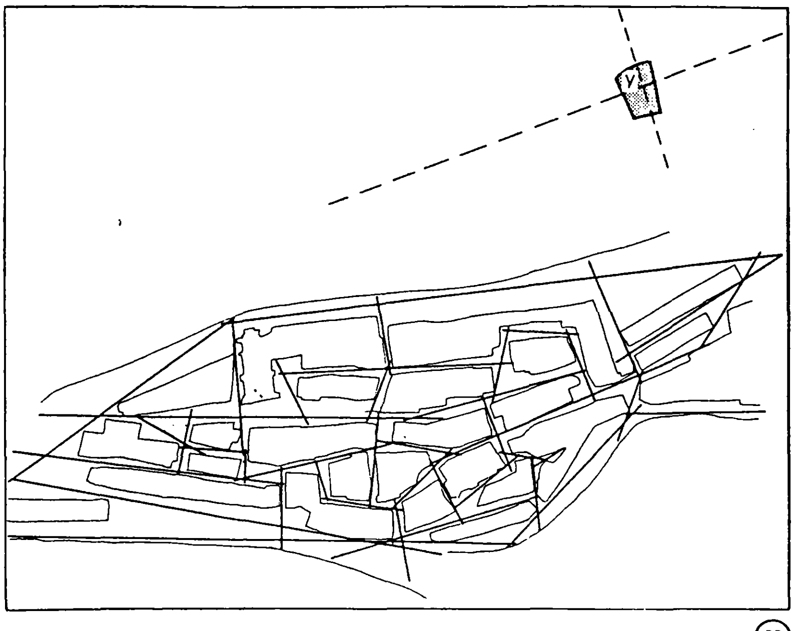


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different from each other capturing the changes an observer experiences rather than the invariants along his experience[205].

The assumption behind this approach seems to be that experience relies on information that is collected from different vantage points.

'Insofar as the fields represent permanent and inherent properties of space, and insofar as they also represent potential experience, philosophically one might lean towards the 'idealist' view of reality as nothing other than the union of all possible experience'.

Thus, Benedict departing from Gibson's notion of information as based on structures rather than on cumulative information falls into the paradigm of intelligibility seen as an empirical mosaic of observations.

- **Spatial experience based on syntactic properties**

Hillier and Hanson describe spatial experience concentrating on the structure of space. For Hillier the key element to structure is the notion of 'configuration'. Configuration refers to the relative arrangement of parts so that changes at a small scale level affect the pattern of the large scale.

Hillier and Hanson focus on how spatial patterns create restrictions or probabilities in patterns of movement, visibility and spatial use[206]. The study of spatial pattern is possible through a description of the two and one dimensional extension of space. These are represented by the 'convex' and 'axial' maps. A convex map is the set of the fattest and fewest convex spaces[207] covering a layout, (illustration 1.68). An axial map consists of the longest and fewest straight lines making all axial links amongst convex spaces possible[208], (illustration 1.69).

Isovists are also used as representational tools accounting for visibility relations amongst spaces. However, they are seen as providing visual information not from a single vantage point but from all spatial points within a convex space. Thus, Hillier and Hanson overcome the problem of limitless

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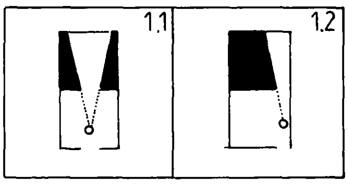
205 Benedict's gradients map points in space from which certain characteristics remain invariant and points from which they change. Thus, instead of representing which physical and geometrical parameters stay invariant across visual fields revealing thus, the structure of visual information, Benedict represents points in which invariants and variants are observed. Thus, experience is presented as an accumulation of changing information rather than as a structured process.

206 Bill Hillier, Julienne Hanson, Ibid.

207 A convex space is the area in which every line connecting two of its points goes inside this space, (illustration 1.67).

208 Ibid., p. 91, 92.

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isovists required to represent an environment. Further, instead of considering spatial experience as a collection of visual fields, they study the structure of these fields.

Spatial systems are analysed in terms of a number of properties the most fundamental of which is 'integration'. Integration accounts for how far every element is from every other element in the system[209]. Integration value identifies elements from which the system is 'shallow', i.e. elements that tend to integrate the system, and elements from which the system looks deep, i.e. elements that are segregated within the system. Integration values are correlated with patterns of movement to observe how these properties relate to the ways a layout is experienced.

Based on the syntactic description as a prerequisite for intelligibility, Hillier and Hanson offer an analysis that captures properties of permeability and visibility in space. Their contribution to spatial experience seems fundamental showing that the changing information provided as one moves in space depends on structural parameters. As opposed to the theories examined so far none of which offers a descriptive account of space, Hillier and Hanson establish a descriptive theory of spatial relations.

Nevertheless, their description is surface free. Corporeality plays an essential role in space affecting permeability, visibility and shape recognition. This is because these parameters are established through patterns of continuities and discontinuities in surfaces.

The examples in figures 1.1, 1.2 can demonstrate the importance of corporeality in a layout. As it was suggested in the introductory part of this research, in figure 1.1 the two spaces are experienced as clearly bounded spaces. In figure 1.2 the two spaces are seen as connected by the continuous surface that defines both. In figure 1.1 the two spaces are seen as two bounded rectangular volumes. In figure 1.2 they are seen as two sub-regions within a large rectangular volume. The more the surface dividing the two spaces is distanced from the right wall the more this layout tends to be seen at a single space.

A description of these layouts based on convexity and axiality does not specify the lack of a connecting surface in the first figure as opposed to the binding surface in the second one[210]. It does not specify the perception of two spaces as opposed to a single space either. Thus, convexity and axiality focusing on

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209 Ibid., p. 108, 109.

210 Hillier suggests that this a fundamental characteristic of a spatial description based on integration. 'It is of interest to note that two forms which have different geometries ... can have similar or different integration values, often in contradistinction to geometrical properties'. Bill Hillier, ' Seeing Buildings: or is Architectural Form Meaningless?', unpublished paper, 1995.

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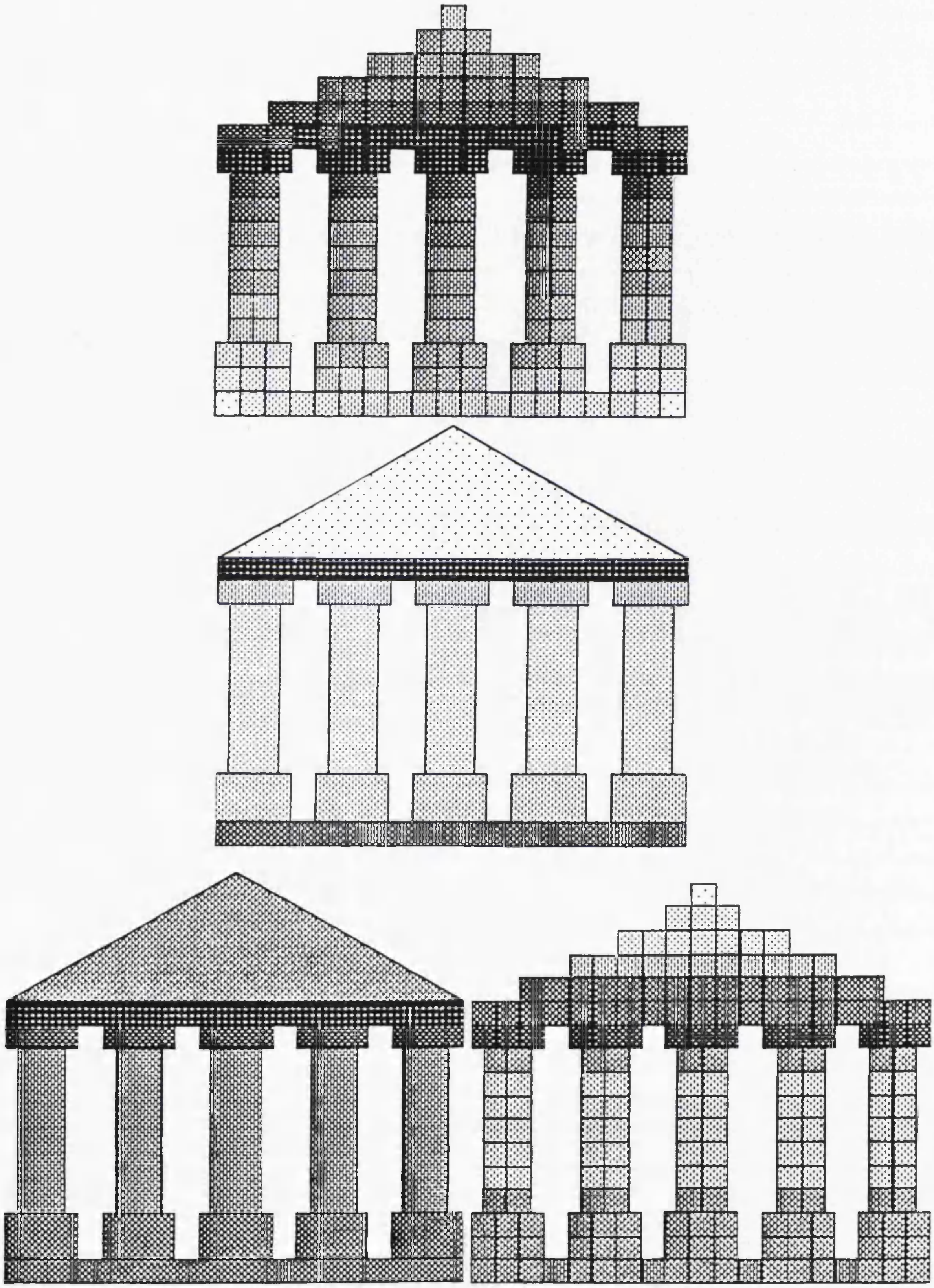

which links are possible rather than on how these links are constructed by the means of physical patterns, edit surfaces and shape out of the description[211].

As the discussions of various authors have shown physical systems are the means by which geometry manifests or buries itself in space[212]. Surfaces follow geometrical contours translating geometrical shape into spatial shape. *Thus, the importance of corporeality lies not only on the effects it has in spatial experience but also on the fact that it translates geometrical properties into spatial and physical properties. Therefore, an analysis that looks at the ways visual properties in space relate to the geometrical properties has to take into account the surface parameter.*

- **GEOMETRICAL PATTERNS**

- **Intelligibility based on syntactic properties**

Hillier attempts to include notions of shape in syntactic description by suggesting that what is understood in a shape is its pattern of integration. This pattern is not captured as a single view but as layered views. One layer is 'metric tessellation', describing shape as a system of small identical elements, another one is a convex superstructure of elements and figures superimposed on the shape, and a third layer is the high level structure of symmetrical or congruent elements superimposed on the form, (illustration 1.70). The structural agreement between these layers is the source of the communication of meaning or signification, whereas the tension between these layers is the source of the aesthetic[213].

In metric tessellations elements are attributed integration values the distribution of which is mapped through gradients of colour. Simple shapes like a circle or a square exhibit a centralised pattern of integration, (illustration 1.71, page 96). Thus, geometrical symmetry is translated into a syntactical symmetry through an equal distribution of integration value. Therefore, intelligibility of geometrical properties for Hillier is syntactical and based on the distribution of integration.

Symmetry is a configurational property opening the way to describe 'balanced asymmetry', i.e. shapes that approach symmetry without being totally symmetrical. This enables an analysis of local and global patterns of symmetry particularly in buildings that use symmetrical figures within an overall asymmetrical pattern and vice versa.

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211 Isovists might introduce surfaces into representation of spatial properties. However, syntactic description puts no emphasis on how the structure of surfaces affects spatial experience.

212 Frankl and Wofflin observed the effects of simple or complicated contour patterns in the recognition of shape and properties amongst shapes.

213 Bill Hillier, 'Seeing Buildings: or Is Architectural Form Meaningless?', unpublished paper, 1995.

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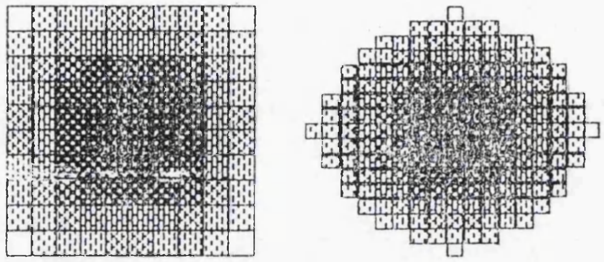

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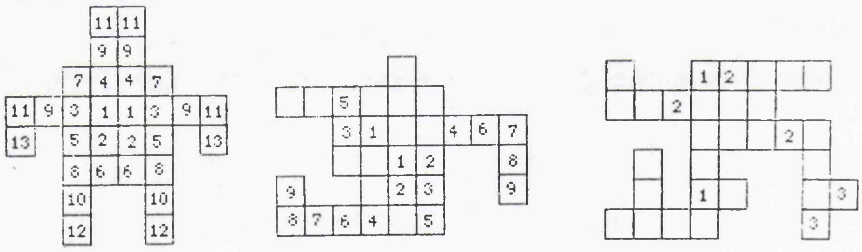

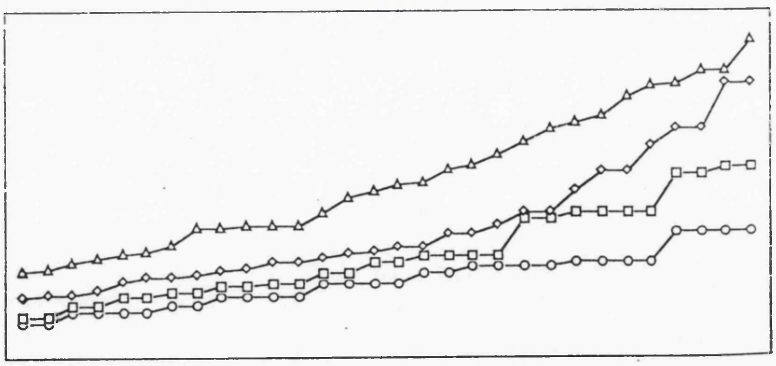

**Observations**

a:si=21/30=.7; b:si=26/30=.867; c:si=11/30=.367

6×5 rectangle si=9/30=.3

(72)

Balanced asymmetry is captured by line charts that represent the equal i-values in a shape as well as the distribution and the degree of integration. Balanced asymmetry or symmetry index emerges as a ratio of the total number of elements to the number of elements that having equal i-value are aligned next to each other to form a horizontal line, (illustration 1.72).

Symmetry index captures the difference between forms that can be understood all at once and patterns that are understood only by moving inside them. The former possess a great deal of similar relationships and are thought of as highly 'ordered patterns'. The latter possess a differentiation amongst elements and a structure like the integration core that links the centre to the edge in several directions. The difference between 'ordered' and 'structured' patterns captures the difference between facades that are seen at once and spatial layouts that are seen through movement[214].

Hillier's notion of the relationship between ordered and structured patterns seems to refer to the relationship between geometrical and spatial properties[215]. This relationship can be studied through a single configurational approach that examines the syntactic properties of formal and spatial systems. Thus, unlike Benedict Hillier identifies the importance of both systems in architecture.

Besides, Hillier's analysis of shape and symmetry as a distribution of integration values overcomes the figurative aspects of shape offering a description based on syntactic properties. It shows, therefore, that patterns are recognised not through their classification into figurative wholes by a perceiving mind but through their laws of integration. Metric tessellations can also open up the road for a description of less symmetrical shapes. According to Hillier neither common sense nor the modern definition of shape as 'invariant under motion' can easily categorise such shapes.

However, as it was suggested in the previous section, group theory seems also to offer a way to describe symmetry breaking through the notion of symmetry reduction under a transformation. As forms descend from higher to lower levels of symmetry sub-groups are defined retaining fewer symmetries. Thus, it could be argued that less symmetrical shapes can be approached through a comparison amongst levels possessing different degrees of symmetry. As Hagen suggests the descriptive economy of the group

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214 The distinction between order and structure was first introduced by Julienne Hanson in an article on the post fire plans for the city of London, Julienne Hanson, 'Order and Structure in Urban Design: The Plans for the Rebuilding of London after the Great Fire of 1666', Ekistics, 334, January/February 1989, 335, March/April 1989, p. 22.

215 Hillier's notion of highly ordered patterns refers to patterns that establishing similar relations amongst various elements become intelligible all at once. It seems, thus, to refer to the notion of geometrical unity as a co-ordination of properties at all different scales. Thus, he defines order in the way Renaissance theories defined it, i.e. as something in which 'nothing can be added or taken away but for the worse'.

theory is founded on the fact that shapes include groups and sub-groups reducing the necessity to look for the infinite possible number of geometrical relations in each particular shape.

Besides, an analytic model as suggested by group theory looks at structure as a process of equilibration between higher and lower levels of order that extend beyond the level of a single configuration. The description of the buckling sphere used by Stewart and Golubitsky, for example, is not based on its own symmetries only. It extends beyond itself to include the broken symmetries of the sphere, a higher level concept. Thus, it seems that metric tessellations breaking up shapes into numerous elementary units freeze patterns into a static description. On the other hand, the analytical model as suggested by group theory traces more than one state of formation implying a dynamic development.

Metric tessellations analyse shape or the combination of elementary shapes without explaining the ways they are put together in an operational way. It identifies rules but not the ways in which these rules evolve by certain operations during a composition process. In this respect, it does not lead to a description of a process of genesis.

Besides, although Hillier suggests that the configurational approach is founded on the relationship between the global and the local scale, he focuses mainly on two dimensional systems like facades. An analysis that isolates facades from a three dimensional structure seems to reflect the unquestioned attachment of architectural tradition to orthographic projection. Evans suggests that this tradition founded on the Renaissance methods of representation has survived regardless of the changes in architectural composition that make orthographic projection a limited tool.

In classical architecture the co-ordination of facades, plans and sections under a single rule like bilateral symmetry makes the separate examination of these systems possible. According to Evans the rules are so clear that a single section through the crown of the vault is enough to visualise a bilateraly symmetrical building as a whole.

In modern architecture, as Baker showed, architects like Le Corbusier replaced the traditional conception of the facade with a facade that results from the operations carried out at the volume as a whole. As Nicolin and Zardini suggested even Botta, who seems closer to classicism, shapes the four faces of the house through the volumetric sculpturing.

Architectural drawings are metric transformations of three dimensional to two dimensional objects retaining angles, sizes, shapes and parallels invariant[216]. As such they are more complete descriptions of the geometrical properties of a building than actual space where information about the properties of shapes and their relations constantly changes.

216 Margaret Hagen, Ibid., p. 102.

However, as it was suggested in part one drawings are also incomplete representations showing not everything of what is to be shown. Plans, sections and elevations capture geometrical relations across two directions only[217]. Axonometric drawings showing all three directions are usually given special attention by architects enabling a more complete visualisation of a building. However, an axonometric is an affine transformation retaining size and parallels intact but changing angles. Thus, architectural drawings leave essential properties of a building outside description hardly managing to cover both geometrical and experiential aspects of this object[218]. As Mitchell suggests 'Drawing ... is the art of knowing what to leave out'.

Configuration, as Hillier defines it, establishes relations amongst elements in such a way, that changes at the local level affect the global one. The difference between the global and the local level or between a three dimensional and a two dimensional object can be captured by a difference in the number of symmetries they possess. A cube, for example has 24 rotational and 24 reflectional symmetries as opposed to one of its sides that has just four of each kind. From the cube to the square, symmetry changes from three dimensional to two dimensional symmetry, from a higher ordered system to a lower ordered one.

A change in the number of symmetries of the volume as a whole will affect the symmetries of the facades. Thus, configuration presupposes that a dialogue is set between the higher and the lower levels of order in which decisions taken at one level affect the other. The combination of conventional devices like models providing knowledge about the building's volume and drawings isolating certain aspects and studying them on their own demonstrates this dialogue between different levels of order. Combining these devices the architect leaps across scales testing how his systems perform across changes.

Composition, then, is a process of equilibration in which oscillations between higher and lower levels of abstraction enable one to control the changes from one state to another. What stays invariant throughout these changes and between the global and local scale is the structure of composition. It is true that facades and plans can be examined separately. However, as group theory shows an analysis that moves from the highest to the lowest level of order can offer an understanding of their integration within the total system.

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217 Plans show relations extending in length and width but not in height, while sections and elevations capture relations in height and length or in height and width only.

218 It should be also mentioned that drawings usually fail to account for a whole range of qualities in space like materials, textures, light conditions or other aspects essential in everyday experience. These qualities are important both at the sensory and the compositional level often clarifying compositional properties. Although the tactile aspects of space are beyond the interest of this research, it should be mentioned that they often become the principal media through which space is experienced. The installations of James Turrel for example demonstrate in the clearest way an experience of space founded purely on light properties.

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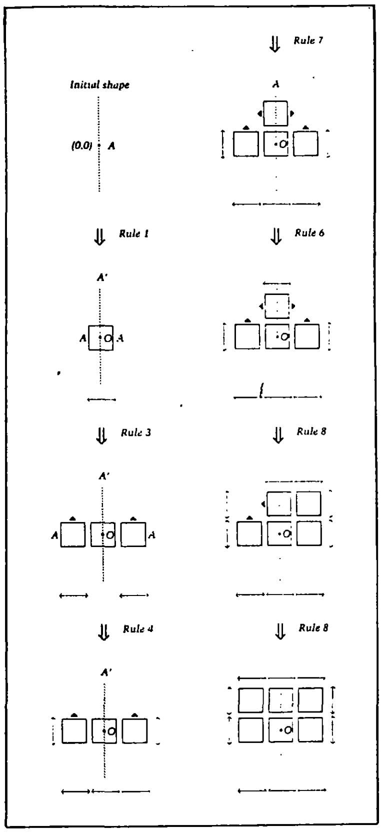
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Rule 6
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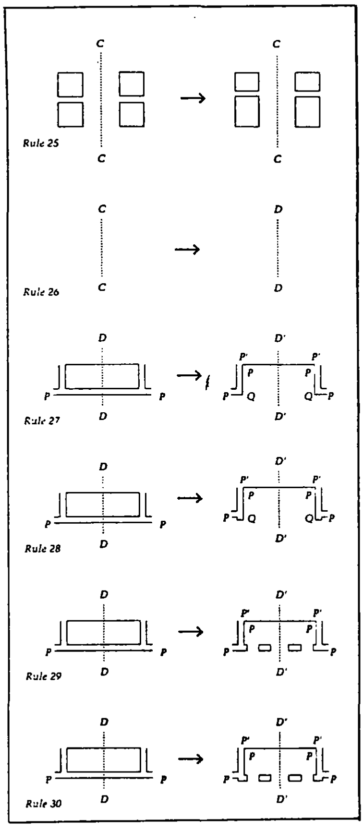
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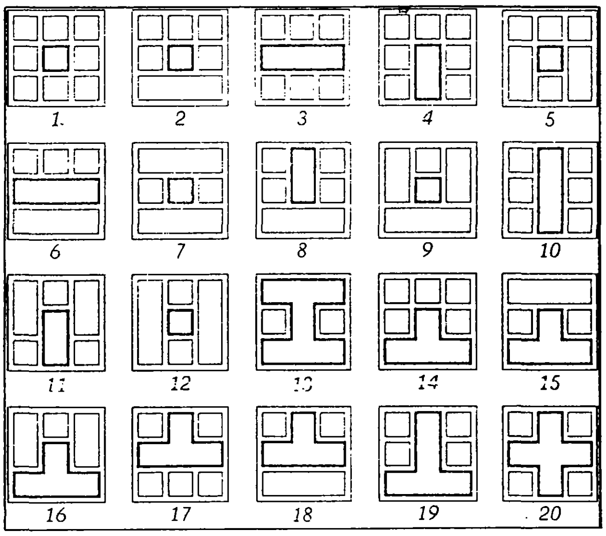
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*Thus, analysis should proceed from the volume to the two dimensional systems like facades sections and plans.*

Nevertheless, Hillier's analytical model based on metric tessellations is under development. Thus, at its present state it attempts to examine formal ideas found in real buildings rather than the formal structure of buildings themselves. The future development of this model at a three dimensional level could provide a method to deal with volumes. However, it should progress from the global to the local scale of facades and plans. It should also be combined with the analysis of space to examine how geometrical properties are captured in visual experience. Therefore, Hillier's approach cannot yet offer a way to solve the problem addressed by this research.

- **Geometrical properties as limitations in a field of genetic possibilities**

Mitchell, Stiny and Steadman attempt to describe geometrical properties from the point of view of their genesis. Mitchell suggests this genesis is a transformation that evolves in states by certain operations. An architect changes the design from one state to the other until he reaches the final one. Transformations may be either preservative or destructive. The first one keeps the properties of an object intact while the second one changes its essential properties[219].

Mitchell distinguishes between a building as a construction in a 'physical world' and a building as a construction of 'graphic tokens', such as points, lines and polygons forming two and three dimensional arrangements in a 'design world'. Transformations are applied to a vocabulary of shapes in the design world which depict corresponding objects in the physical world. These depictions are the conventional modelling techniques and the architectural drawings.

Thus, for Mitchell composition progresses through transformations applied to architectural drawings consisting of graphic tokens which can be manipulated according to certain grammatical rules[220]. Once the tokens have been established description proceeds in establishing the relations amongst them.

Mitchell and Stiny have developed what they call a 'Palladian Grammar' using a concatenation of 'graphic tokens' or rectangular cells[221], (illustration 1.73). They establish a vocabulary of rules that enables a step by step generation of Palladian layouts and variations of these layouts, (illustration 1.75). This is based on eight main stages defining grid, wall, room layout, interior wall alignment, principal entrances and so on, (illustration 1.74).

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219 William Mitchell, Ibid., p. 113.

220 Ibid., Preface.

221 Ibid., p. 152-181.

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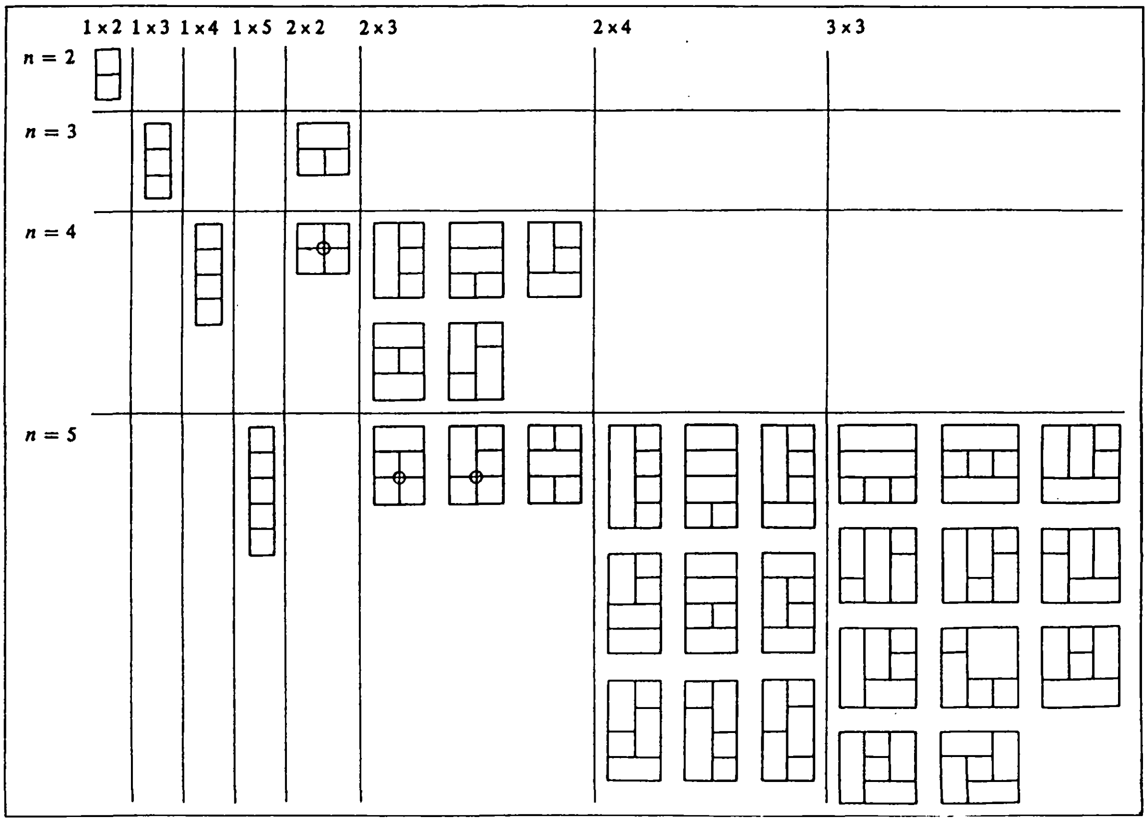

Steadman has devised another approach based also on cell configurations. Using a computer programme he has studied the geometry of plans as depending on limitations to geometrical possibilities[222]. These possibilities refer to the possible dissections of a rectangle into smaller rectangles and squares, (illustration 1.76).

Mitchell's and Stiny's shape grammar defines compositional rules step by step enabling a description of composition as a transformations process, encoding plans and showing how to reproduce them. Thus, it seems to approach intelligibility and composition with a single theoretical and analytical framework providing knowledge about how things are put together to generate layouts.

However, instead of examining the relationship between the volume, the plans and the facades, they focus simply on plans. Besides, even when looking at plans they first individuate architectural components like room cells and then they examine their relationships. This approach might seem possible only in layouts where grid units correspond to room cells that are all symmetrical on a single axis. In irregular layouts like those of Le Corbusier an increased emphasis on a fluid, asymmetrical and complex arrangements of shapes makes the application of shape grammar impossible. Even in less irregular arrangements like Botta's plans it is often difficult to discern discrete spatial enclosures and specify their connections by a concatenation of regular cells.

Like Mitchell and Stiny, Steadman examines how changes in geometrical structure produce different results. This way he studies possibilities that provide knowledge of the limitations in a field of architectural freedom. However, in his approach, overall geometrical patterns result also from local scale combinations amongst individual rectangular or square units. Thus, although composition is approached as a transformation process, this process is reproduced by local rules of articulation amongst individual shapes.

Instead of looking at how geometrical order develops as an interaction of higher order concepts, like overall symmetry and external wall alignment, with the lower levels, these authors approach composition in a reverse order. Overall geometrical properties result from the concatenation or dissection of local elements rather than from an interaction amongst different levels of order.

Besides, it seems that they are more interested in the generation of possible layouts based on permutations of cell units than in the study of a particular layout and its process of genesis. It is true that awareness of what possibilities exist in design offer an architect a larger repertory of choice and increase his combinatorial capacities. However, composition is not simply about how many combinations exist but about how the designer exercises choice creatively over these combinations. These authors seem to reduce combinatorial creativity to a combinatorial activity seen as a mere structural possibility.

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222 J. P. Steadman, 'Architectural Morphology', Pion Limited, 1983, p. 2.

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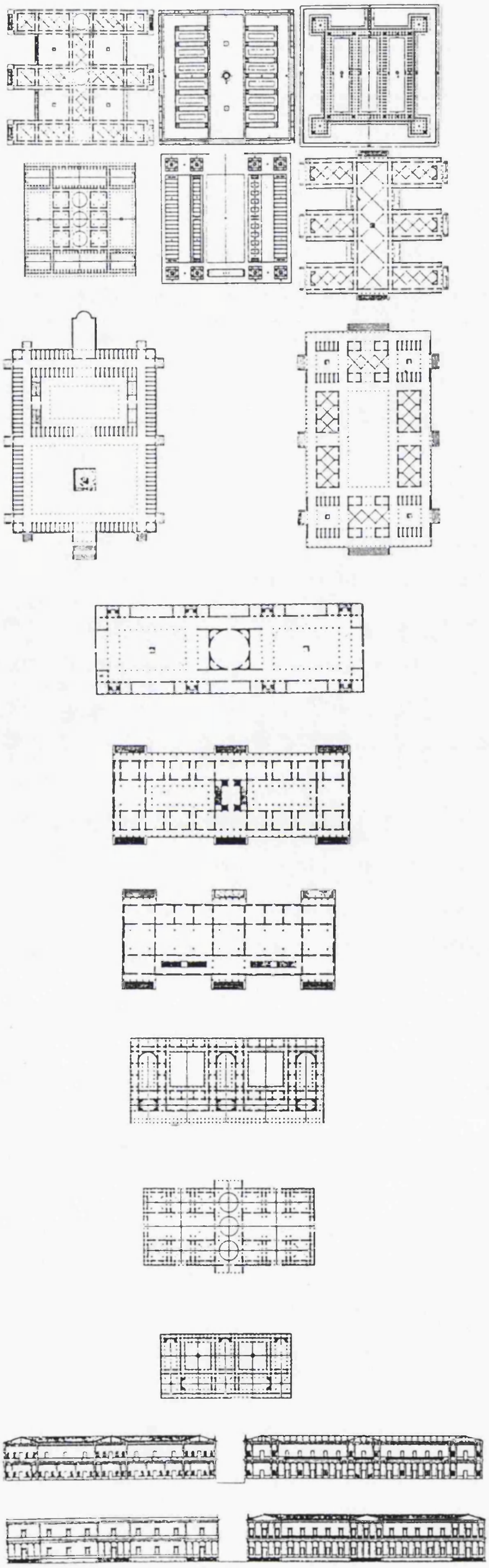

(77)

It could be argued that this approach is similar to Durand's approach who looking at architecture as a combinatorial possibility reduced the creative subject to a degree zero[223], (illustration 1.77). The absence of a subject from the approach of these authors is also reflected in their decision to focus on geometrical properties ignoring the ways these are understood by a mobile observer in space.

To summarise, the theories discussed in this section move away from classical descriptions based on hierarchical norms of mathematical and geometrical order. Classical theories stress one particular kind of geometry. These theories focus on relations making a discussion of buildings that exhibit less strict kinds of order possible.

However, the problem of the ways geometrical properties relate to spatial experience is not solved. This is because these authors look either at the spatial or at the geometrical properties of buildings. Hillier is the only exception attempting an analysis of both by a single theoretical and analytical framework. However, his analysis of geometrical properties is still at an experimental level. As such it cannot enable a combined analysis of the two levels of properties.

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223 Mario Galdesonas, Ibid., p. 18.

## • COMPARATIVE DISCUSSION OF THEORIES - Towards a theoretical and analytical framework

With the theories discussed in the last section the examination of the research problem in the context of the existing literature comes to its final stage. Moving backwards from recent to classical theories and forwards to recent theories this discussion identifies the large part this problem plays in the development of architectural discourse. In the origins of this development lies a conflict, two irreconcilable extremes. Intelligibility is dominated either by abstract-geometrical or by visual-sensual pattern, (classical-empirical theories). At the other end lies a reconciliation. Geometry and the appearance of things are aspects of the same reality, (Frankl , Hillier, Evans, Hagen). In between lie theories full of contradictions that on the one hand place geometry into the world of visual appearance, while on the other into the world of the intellect, (Rowe, Arnheim).

All kinds of theories make an important contribution to the subject of this research. The first category has generated a conflict that has helped to identify the importance of both kinds of properties in intelligibility. The second category closes the gap left by the abstract-visual contrast suggesting that geometry is embedded in the world of experience. Finally, the third kind of theories revealed that geometry organises events in a synchronous plane whereas space unites these events through sequential experience, (shallow-deep space, compositional schema-architectural vistas).

From the theories belonging to the second category Hagen and Piaget pointing at the significance of transformation, make the most important contribution to the question addressed by this research. Hagen suggests that geometrical properties can be studied in terms of the ways they relate to spatial properties through the notion of invariant along a transformation. The sequential plane of visual information is geometrically determined by properties that stay invariant as a person moves in space.

By placing geometry in the structure of visual information, Hagen seems to unite the synchronous plane of geometrical and the sequential plane of visual properties in spatial experience. If the former consists of the total set of geometrical characteristics independently of the observer's existence and if the latter consist of invariant and variant geometrical characteristics, then the notion of geometrical invariance is what unites the two planes. *The synchronous plane of geometrical and the sequential plane of visual properties could be seen as two overlapping entities the intersection of which is taken by the geometrical properties that stay invariant in visual information.*

Hagen also suggests that group theory offers not only a way to study the relationship between the two planes but also an economical description of geometrical properties. Instead of breaking a system into numerous components and describing their relations, it achieves an economical description that considers a system as descending from higher to lower levels of order. Besides, group theory describes shape as a structural rather than as a figurative entity distinguishing between the image of an object and its structure. It also offers a way to describe 'symmetry breaking' or systems that posses lower levels of symmetry than elementary geometrical systems.

Piaget suggests that the description of an object becomes also a description of its mechanism of genesis. The notion of genesis implies at the same time a subject. This is neither an extrinsic entity to which figurative wholes exercise their power nor an entity that attaches these wholes to patterns. It is a creative subject that is involved in a process of 'reflective abstraction'[224]. The performance of the operations enables him to abstract the properties of the group and reflect them creatively in future operations. *What follows from Piaget's observations is that composition is as an intentional act of a creative mind that articulates the internal laws of an object through a process of reflective abstraction.*

At this point the question that is raised is: *If group theory offers access to geometrical properties as well as to the ways they relate to the spatial properties, is it possible to define a common theoretical and analytical framework that studies the above based on the notion of invariant along a transformation? Besides if this notion offers access to composition is it possible to construct a common framework that describes intelligibility and composition at the same time?* To answer these questions a re-examination of the ways architectural theory has approached composition is needed.

- **COMPOSITION VERSUS SPATIAL EXPERIENCE**

Although it is Piaget who clearly points out that the description of relations carries with it a description of composition, the majority of theories examined so far are implicitly dominated by a constructive consciousness. The Renaissance theories installed a specific kind of mathematical and geometrical order as a system that aids architectural creation. In their creations the role of a perceiving subject in space is clearly addressed. In their theoretical descriptions, though, it is given almost no attention.

Further, the emphasis these theories put on the idea of beauty expressed by a hierarchical application of rules from the building as a whole down to its smallest detail reflect a belief that composition is an intentional process. In this process the creative mind intentionally preserves and intensifies the properties determining unity at a highest level of abstraction through the articulation of the lower levels.

The significance of geometrical properties that establish synchronous relations amongst elements that are separated in space was denied by the empirical theories. What matters most is not how these elements are put together but the space the body occupies and the ways it looks to the eyes of the observer. These are the only preconditions of intelligibility. Another kind of constructibility was carried by these theories. If

224 Jean Piaget, 'Structuralism', Routledge & Kegan Paul, 1971

elements and spaces are discovered through observation, they come together as a system of sensory tactile experiences[225].

Thus, the division between the world of the abstract and the world of the visual, the corporeal and the incorporeal, the intellect and the senses includes a division between composition and space, geometry and spatial experience. Composition has been associated with an arrangement of geometrical elements that make sense on a drawing board. Inside a building geometry cannot jump out of the drawing or a facade and clarify perception, (Scruton ).

The implication seemed to be that the composing architect articulates geometrical relations and not relations in space. Nevertheless, as Evans has suggested the composing architect holds geometry in his mind as an element that aids the construction and visualisation of the building[226]. This mind stands in the middle of 'a nexus of communication amongst the extreme states of the abstract and the real' capable of dematerialising architecture into its geometrical properties as well as of constructing architecture through these properties.

If de-materialisation in experience depends on the fact that man constructs these forms then what he captures is a process of construction. On the other hand, if construction depends on the ability to grasp abstract properties what the designer captures is a process of de materialisation of his object of creation into its geometrical properties. Thus, Evans seems to imply *an alliance between the designer and the observer, the 'performer' and the 'spectator'[227], composition and experience, geometrical and spatial properties.*

Therefore, a description of the relationship between geometrical and spatial properties from the point of view of the observer is a description of this relationship from the point of view of a composing mind. *The question of how these systems become intelligible to a viewer carries with it the question of the ways they become intelligible to a composing architect.*

- **COMPOSITION AND INTELLIGIBILITY BASED ON TRANSFORMATION**

Apart from the Renaissance theory, four other kinds of theories can been identified in terms of their picture of composition: Theories of figurative wholes suggesting that the designer chooses from a pre-structured vocabulary of wholes, (Arnheim). Theories suggesting that the designer chooses from possible combinatorial relations, (Hillier). Theories seeing composition as a set of limitations on combinatorial

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225 Or as often implied by Colquhoun as a system of social purposes.

226 Robin Evans, Ibid., p. 359.

227 These terms are used by Peter Eisenman, Peter Eisenman, Ibid.

possibilities, (Mitchell[228], Stiny, Steadman). Theories of transformation suggesting that the designer articulates relationships between higher and lower levels of structure, through invariants and variants along a transformation, (Baker, Eisenman, Piaget).

Arnheim's, wholes are 'compositional schemata' the designer starts his work with[229]. They are concepts of hierarchical significance, selected from a vocabulary of instances and manipulated to form complex patterns. They are *manufactured* facts rather than facts *constructed* during a process. His description seems, thus, a description of wholes without a composition.

As Hillier has suggested composition is characterised by 'configurational intent'[230]. This means that it deals with intentional interrelationships of elements invoking a creative subject. Architecture is distinguished from buildings when there is evidence of a deliberate 'abstract comparative thought' applied to the organisation, construction and arrangement of space aiming at innovation rather than cultural reproduction[231].

Thus, composition is not mere combinatorial possibility. It is about the intentional application of 'intellectual choice exercised in a field of possibility' and based on 'general comparative knowledge of architectural forms and functions'. Architecture creates tensions between the different levels of form as opposed to the vernacular buildings that create a correspondence between these levels. This tension generates ambiguity that releases complex possibilities for meaning 'in much the same way as good poetry creates fields of possibility meaning rather than simple precise meanings in the manner of everyday language'[232].

Thus, Mitchell's, Stiny's and Steadman's emphasis on combinatorial possibility that derives layouts from a local level of properties leaves composition with an aggregation of 'graphic tokens' and no human agency controlling their combinations.

This agency for Hillier manipulates comparative knowledge of relations and creates a tension amongst the different levels of relations with an emphasis on the release of possibility of meaning. However, although Hillier recognises a human agency at work, he sees composition in a state of arrest. Thus, he looks at architecture as an end product when choice is exercised and rules are crystallised in the form of a

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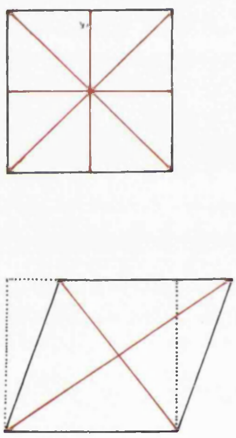
228 Mitchell's idea about design primitives or design tokens seems also influenced by the notion of figurative entities.

229 Rudolf Arnheim, 'Towards a Psychology of Perception', University of California Press, 1966 p. 116.

230 Bill Hillier, ibid.

231 Bill Hillier, 'Specifically Architectural Theory', Harvard Architecture Review, Vol. 9, 1993, p. 10.

232 Bill Hillier, 'Seeing Buildings: or Is Architectural Form Meaningless?', unpublished paper, 1995.



1.3

known result. *Nevertheless, from the point of view of composition the ways this end product is formed during the internal operations of design is as much interesting as the product itself.*

Composition is not an activity with a known predetermined result. In Hillier's words it aims at innovation rather than reproduction. Thus, the composing architect does not have the result of his creation as an arrested image in his mind prior to its generation. If it was so there would be no innovation providing that what one knows prior to construction is an existing field of realities, the field of comparable knowledge, rather than the field of potentiality and architectural freedom.

An architect might have a general pre-intention of what he wants to achieve which might range from an arrangement of configurations, to a process route uniting certain spatial events or a combination of certain materials expressing certain abstract concepts. However, the realisation of these intentions is processed through the development of systems of forms not known in advance and discovered during a construction process. This process takes these systems from one state to another, as Baker and Mitchell show, revealing the field of possibilities in which the designer exercises his choices. Thus, possibility, potentiality and freedom are activated and released through construction.

A simple concept like a square, for example, is not about structural relations only but also about the transformations that leave these relations intact. A rotation or reflection will sustain a square. A stretch, though, will affect its angles and change it to another category of shape. The new shape has reflective symmetry only on the diagonal axes and rotational symmetry only on a 360° turn, (figure 1.3).

It is essential to understand the mechanism of transformation in order to understand what possibilities exist in the manipulation of form and how certain changes affect form and meaning. A designer, thus, exercises choices not simply over combinations but over transformations that take rules from one state to another. The field of possibility is a field of transformations and not simply a field of geometrical relations. As the designer prefers one possibility over a set of others the set of possibilities gradually closes down bringing him closer to the final product.

In this the way, he clarifies the object of his creation obtaining gradual knowledge of its geometrical rules. Thus, composition seems to be an intentional act in which the composing mind gradually obtains knowledge about the object of his creation. This knowledge is aided by transformations that are intentionally applied and represented on two or three dimensions through flat projection and modelling.

Besides, since projection is an incomplete medium of a composition it is incomplete in transmitting information not only about the final state of the building as a whole but also about the building during its process of genesis. Thus, it could be argued that even at the latest stages of design the knowledge a designer has of a building he designs is based on properties constructed and represented on drawings.

Although at this stage the designer's knowledge is closer to the actual event than an observer's knowledge, he has an incomplete knowledge of this event.

Considering the observer's comprehension of a building as depending on the properties of its genesis and this genesis as depending on a process of transformation there seems to be an intrinsic relation between design and experience. If a building becomes knowable by an observer through its rules of transformation, it becomes knowable by a designer through the same rules. Thus, an analysis based on transformation becomes an analysis that ties up composition and experience.

*Therefore, analysis of the ways the geometrical properties relate to the spatial properties has to offer access to the process of genesis of this relationship. The examination of theories at this section seems to reaffirm that analysis should approach these issues from the point of view of invariants along a transformation.*

- **COMPOSITION, GEOMETRY AND SPACE**

This discussion suggested also that composition is a creative act that arranges relations between the synchronous plane of geometry and the sequential plane of space, (Rowe, Baker, Frankl, Arnheim). Arnheim drawing an analogy with a play suggests that similalry to Shakespeare who uses a roundabout way to introduce the audience to the core of the plot, the composing architect uses architectural vistas to introduce the observer to a geometrical core.

'When a work based on linear succession narrates a story, it actually contains two sequences, that of the event to be portrayed and the path of disclosure. In a simple fairy tale the two coincide. The account duplicates the order of the events. In more complex works the journey that the author prescribes for the spectator or reader may differ considerably from the objective sequence of the plot'[233].

In architectural composition, the event to be portrayed is the building itself with its sequences of spatial events encountered gradually as the viewer moves in space. The path of disclosure is the order of these events at the synchronous plane of geometry. *Composition, therefore, is not simply concerned with relations in the synchronous plane of geometry as the classical theories implied. It is also concerned with the spatial sequences in which geometry is viewed in space.* The analysis of buildings by Le Corbusier and Botta is hoped to test this hypothesis.

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233 'For example, in Hamlet the inherent sequence leads from the murder of the king through the wedding of his queen and brother to Hamlet's discovery of the crime, and so to the end. The path of disclosure starts somewhere in the middle of the sequence, and moves first backward and then forward. It proceeds from the periphery of the problem towards its center, introducing first the watchmen, then Hamlet's friend, then the mysterious ghost', Rudolf Arnheim, 'Art and Visual Perception', University California Press, 1974.p. 337.

- **GEOMETRICAL UNITY AND INTELLIGIBILITY - (Geometrical shapes, structure and representation)**

For Arnheim the synchronous and the sequential plane can either coincide or they can have a more complex relationship being different from each other. Rowe also pointed out that in Le Corbusier there is a tension between shallow and deep space. Nicolin, Zardini and Trevisiol showed that in Botta the geometrical relations are clearly portrayed in space allowing the unity of the volume to be visible in the interior. The hypothesis put forward at the end of part one was that the tension between the two levels of properties in Le Corbusier seems to be generated by a simultaneous employment and negation of geometrical rules. On the other hand, the correspondence between these properties in Botta is due to a geometrical unity characterising the building as a whole.

The notion of geometrical unity and its effects in intelligibility seems to pervade almost all theories. For the Renaissance theory, unity identifies with a system which co-ordinates all elements under a single geometrical axis or a commensurable ratio. For Wittkower, Sartoris, Colquhoun and von Moos it identifies with a simple geometrical shape. For Arnheim it refers to a geometrically simple whole. For Frankl and Wofflin it refers to simple geometrical relations amongst clearly identifiable components. For Eisenman and Baker it identifies with an archetypal solid that becomes distorted during construction. For Hillier it refers to highly ordered patterns that establish similar relations amongst every element in a configuration.

It seems, thus, that geometrical unity is associated with an economy that integrates the elements in a composition into a single system and makes it easily understood. This system leads usually to the perceptual isolation of a simple symmetrical shape and its axis of symmetry. As Evans pointed out this kind of economy in architecture was not simply a device to integrate the components of a building but a device to facilitate the drawing and visualisation of a building.

According to Phill Tabor symmetry was seen as the key to composition containing this information-economy argument in its favour[234]. From Durand and Viollet-Le-Duc to the Gestalt theory and Gombrich, Tabor says, 'symmetry implies redundancy of information: to look at one side tells us all we need to know about both sides'. This confidence permits us to focus on detail without fear of

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234 'When a given area is bounded by ...square, there is less perimeter than when by parallelogram, and still less by ... a circle. ...It will be evident that a building will be proportionately less expensive, the more symmetric, regular and simple it is'. Jean Nicholas Luis Durand , Pecis des Lecons d' Architecture Donnes a l' Ecole Royale Polytechnique, Paris 1819, vol. 1, p. 7-8, from Phill Tabor , 'Fearful symmetry', Architectural Review, May 1982, p. 23.

misunderstanding the whole (which partly explains the devaluation of detail in the symmetric compositions of the Modern Movement)'[235].

The significance of the perceptual isolation of a simple configuration is discussed by Piaget in his distinction between perceptual and operational structures. He suggested that although both structures are important, the former are subordinate to the latter. Hagen on the other hand proposed that there is no distinction between perceptual schemata and invariants which form informative structures in the light. Stewart and Baker Golubitsky also pointed out that a simple shape is a group of transformation and not a single image.

Nevertheless, the persistence by which an arrested figure dominates ideas about intelligibility seems to demand a clarification of the relationship between this image and a structural pattern. Hagen's suggestion that geometric shapes identify with the transformation rules seems to offer a solution to the inherent dilemmas between structural and figurative concepts. 'In geometry, the mappings, the transformations themselves, are the elements of the group. Do not be led to believe otherwise by the classic whole-number system example of group'[236].

If a geometric shape like a circle is a group of symmetries or transformations that leave it invariant, then it captures both structural and figurative aspects of its nature through its physical presence. If the rule is the set of abstract properties then the physical aspect of the circle carried through its contour, is both the embodiment and the representation of these properties.

Thus, a circle is a system based on rules that are represented on its physical contour. It is its nature of being both abstract and real, incorporeal and real, operational and representational that seems to be the cause of all confusion regarding the relationship between these extremes.

Evans has suggested that 'in geometry geometrical figures are not the media, but in architectural design they are, since their task is to convey shape from one state to the another. In this sense they are just surely media as the inks with which they are drawn'. Evans seems to point exactly at the property of geometrical shapes in composition to constitute and mediate their structure. However, in both geometry and composition geometrical shapes have the peculiar property to be the vehicles and the mirrors of their structure.

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235 Phill Tabor, Ibid, p. 23.

236 Margaret Hagen, Ibid., p. 31.

Discussing the role of images Evans seems to reaffirm Hagen's distinction between geometrical and arithmetic groups.

'The magic in pictures is often explained as due either to their transmission of feeling or to their mimetic properties, but it is more likely that their inexhaustible mystery arises from the fact that they externalise an aspect of perception, or that they appear to externalise it, as if one were seeing the thought itself, which does not happen with words or numbers in the same way'[237].

Coming back to the geometrical circle, it seems that the four structural properties of the group, i.e. closeness, identity, associativity and reversibility, give it unity and wholeness bringing it directly to the level of figurative concepts represented by its contour. *Thus, it could be argued that the highest the levels of symmetry the more the identity of a shape as a figurative entity is captured.*

It seems that the emphasis architectural theory has placed on the notion of a building's form as a single shape reflects a confusion regarding the distinction between structural and figurative parameters. The structural and representational oneness of this closed system captured by a single physical entity seems to have lead architectural theories to consider geometry not as a system of structures but a system of individual entities or platonic shapes.

On the other hand, this structural and representational oneness seems also to have determined the immense emphasis Renaissance theories put on simple shapes like the circle or the square as constituting and representing notions of unity, balance and wholeness. It also seems to have determined the development of a hierarchical system in which rules are applied from the whole to the smallest detail as the only way to achieve compositional unity at the level of the building as a whole.

It could be also argued that the structural properties of the elementary shapes seem to explain why absent elements like the centre or the axis of symmetry in a circle or a square are observed. The centre is the point from which any axis on which these shapes exhibit reflective symmetry passes. Rather than being attached to the object by the mind, the centre and the axis are part of the description and this is the way they becomes recognised.

Thus, perception and intelligibility become intrinsically interrelated through the notion of rules of transformation represented by geometrical shapes. In this context Gestalt laws identifying geometrical concepts like simplicity, unity and wholeness seem relevant to the laws defined by group theory. It could be suggested that visual patterns take the best form possible not because wholes are perceived but because of a process of reflective abstraction in which local levels of articulation are intrinsically related to the higher levels and reproduce them by a reversibility of the transformation process.

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237 Robin Evans, Ibid., p. 357.

Gestalt laws can be valid if seen not from the point of view of wholes but from the point of view of relations between higher and lower levels of geometrical order. Thus, it is the theoretical basis of Gestalt theory putting intelligibility to the perceiving mind that seems to have generated the problems in their approach rather than the laws themselves.

## • TOWARDS AN ANALYTICAL FRAMEWORK

At this stage the question that arises is: *How can an analytical framework based on the notion of invariance along a transformation that describes geometrical properties and the ways these relate to spatial properties be defined ?*

A study of intelligibility in architecture based on the suggestion that geometrical invariant is the medium between the geometry and experience would have to raise the following question: *Which are the geometrical properties that staying invariant as a person moves in space give access to the geometry of this space?*

This question can be divided into three questions. *Which are the geometrical properties of a layout independently of the observer's existence? Which are the geometrical properties that stay invariant as a person moves? Which is the relationship these properties have with the total set of geometrical properties of the layout?* The development of an analytical model that makes the answers to these questions possible is attempted in the following chapter.

### • Summary

To recapitulate, the review of the existing literature in part one enabled a clearer definition of the research question as being about the relationship between the geometrical properties that are synchronously grasped and those properties that are understood through movement in space. A hypothesis formed about the two architects suggested that in Botta the two levels of properties correspond, whereas in Le Corbusier they take opposite directions.

In Part two the problems arising from a dichotomy between geometry and spatial experience were addressed, suggesting that geometry is embedded in the architectural object in a way that geometrical invariants are captured during spatial experience.

Finally, part three proposed that this dichotomy reflects a split in the existing methods of description which focus either on formal properties or on spatial properties. This can be overcome by looking at formal and spatial description as a transformation process that captures the genesis of an object by reversing the transformation. In this way, a description of form, space and their relation becomes a description of composition.

# Chapter two

# A MODEL FOR ANALYSIS

## • INTRODUCTION

This chapter attempts to establish an analytic approach to the relationship between the formal-geometrical and the spatial properties of buildings. It looks at elementary examples of layouts with a view to develop the basic concepts and strategies that are necessary for the analysis of more complex cases like the buildings selected by this research.

In the previous chapter some first propositions were put forward concerning the structuring of an analytic approach for dealing with the research question. These propositions are the following:

- Analysis should distinguish between the two levels of properties and examine them separately as well as in relation to each other.
- Analysis should examine both levels of properties as groups of transformations.
- These levels can be thought as overlapping circles, the intersection of which describes the formal properties that stay invariant as a person moves in space.

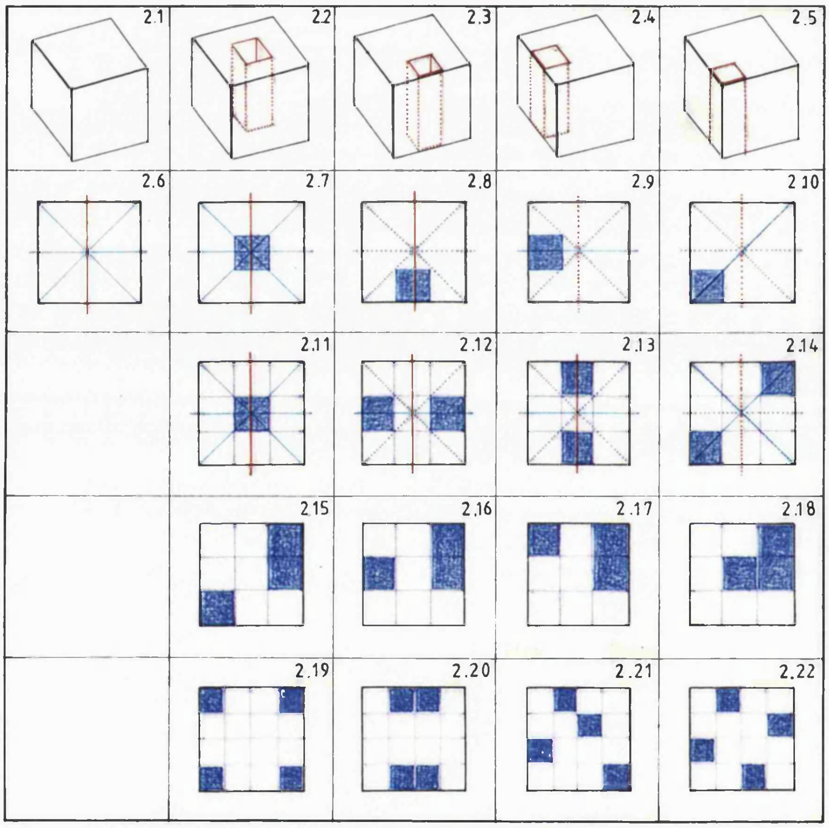
The question this chapter addresses is: *Is it possible to define a common analytical framework that accounts for both levels of properties based on the notion of invariance in a transformation?*

The theoretical discussion also leads to the conclusion that a description of form, space and intelligibility can be based on a description of composition. Thus, the second question raised here is: *Can a description of formal and spatial patterns explain composition and intelligibility in a way that the former becomes the source for the latter?*

This chapter is divided into two parts. The first one examines basic configurations in relation to their formal properties. This examination progresses in stages from simple to more complex shapes establishing a description of formal patterns as transformations. It leads to the identification of three layers of formal properties: shape, grid and physical properties. A number of initial conclusions are drawn suggesting that intelligibility depends on the structural parameters that establish relations amongst these layers. When the same principles remain invariant in all layers of properties, a single interpretation is reached regardless of possible secondary levels of readings incorporated in a configuration. When each layer preserves different principles, a multiplicity of interpretations is constructed. These interpretations are in a tension with each other.

This part also establishes the criteria for the identification of higher and lower levels of formal description necessary to define the analytic stages in the transformation of more complex configurations. These are: the parameter of scale, the parameter of physical identification of elements based on a physical integrity of their defining elements and an economic description. In this way, the analytic stages are defined based on the possibility to distinguish physically identifiable large scale elements from smaller ones that enter into a transformation that is described in the most economical way.

Part two extends into the area of spatial properties seeing them as transformations in a visibility field that changes through movement in space. It leads to the identification of an analytic technique for dealing with the structural parameters of these transformations. This is the ***overlapping space modelling*** defined as a technique that draws intersecting convex spaces in a layout. The area of the intersection or the area of overlap defines the integration of visual fields produced from different convex elements, or otherwise what stays invariant in the transformation of visual information produced inside these spaces. The overlap area defines also invariant physical and geometrical characteristics in the form of boundary surfaces and their geometrical lines. In this way, overlap captures invariant spatial, physical and geometrical characteristics bringing representational tools, the designers use, and formal order into the level of analytic representation and spatial experience.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- **PART ONE**

- **GEOMETRICAL - FORMAL PROPERTIES.**

To examine how it is possible to construct an analytical approach to geometrical properties accounting for invariants along a transformation one can begin by elementary configurations like the ones used in figures 2.1, 2.2, 2.3, 2.4, 2.5.

A first description of these configurations recognises them as volumetric shapes and can easily identify their similarities and differences. Figure 2.1 is a cube, (S1). In the rest of figures , 2.3, 2.4, 2.5 a volumetric rectangle (S2), occupies the centre of S1, (figure 2.2), its front, (figure 2.3), its left, (figure 2.4), and finally its front left side, (figure 2.5), resulting in a new configuration, (S1, S2).

Although it was suggested that analysis should proceed from the volume to the plans, sections and elevations, some basic observations can be put forward by looking at horizontal sections through these volumes, (figures 2.6, 2.7, 2.8, 2.9, 2.10). This is to avoid the complexity arising from a description in three dimensions.

In the first figure there are four rotational and four reflective symmetries. This means that it can be rotated in 90°, 180°, 270° and 360°. It also means that it can be reflected on the central and the diagonal axes. Both rotation and reflection keep the shape unchanged. In figure 2.7 (S1, S2) retains all symmetries of S1. In figures 2.8, 2.9, 2.10 these symmetries are reduced to a single rotational symmetry, a turn through 360°, and a reflective symmetry on the vertical, the horizontal and the diagonal axis respectively. Thus, whereas in figure 2.7 all symmetries of S1 are valid for (S1, S2), in the rest of figures a number of symmetries are broken. In this context, a second description recognises these configurations as transformations in which certain symmetries are reduced while others are kept invariant.

At the level of the three dimensional description the same characteristics could be observed. The number of broken and preserved symmetries, though, is different. This is because a cube possesses 48 symmetries instead of 8. However, the purpose of this analysis is not to identify the number of symmetries but to investigate the ways these symmetries evolve in a transformation. Thus, at this point analysis can proceed by examining properties in two dimensions.

There are cases, though, in which a horizontal section cannot replace a volume. As Arnheim suggested certain buildings require the combination of more than a single section to examine relations that change along the third direction. Reference to these cases will be made later.

- **Shape and grid properties**

Figure 2.11, (p. 115), is derived from figure 2.7, (p. 115), by the extension of the lines defining S2. These lines divide S1 into nine square units. In figures 2.12, 2.13, 2.14, (p. 115) two squares, S2, and S3, are superimposed on S1 each of which coincides with a grid unit.

Two different views of these figures can be taken into consideration. One looks at a configuration as a square grid, while the second one looks at it as a combination of shapes. The configuration seen as a grid possesses all the rotational and reflective symmetries of S1. In figures 2.12 and 2.13, (p. 115), the configuration seen as an arrangement of shapes displays two reflective symmetries on the vertical and horizontal axes and two rotational symmetries, through a 180° and 360° turn. In figure 2.14, (p. 115), it has a single reflective symmetry on the diagonal axis and a rotational symmetry through a 360° turn.

Thus, whereas the arrangements seen as grid lines retain all symmetries of the initial square, seen as a combination of shapes they reduce the number of symmetries. *This shows that when shapes are combined two kinds of properties are created: **grid and shape properties**. These can take either similar or different pathways in a transformation.*

- **Geometrical patterns seen as layers of shape and grid properties**

One may continue introducing shapes on the grid to observe how configurations are intelligible as shape and grid properties preserve different kinds of symmetries.

Figures 2.15, 2.16, 2.17, 2.18, (p. 115), result from the superimposition of a square occupying a grid unit and a rectangle occupying two grid units on S1. At the level of shape properties none of the symmetries of S1 is retained[1]. Thus, similarly to figures 2.12, 2.13, 2.14, (p. 115), symmetry is preserved at the level of grid properties and broken at the level of shape properties.

However, whereas in figures 2.12, 2.13, 2.14, (p. 115), the shape properties retain certain symmetries of the initial square, in figures 2.15, 2.16, 2.17, 2.18, (p. 115), all shape symmetries are broken. Whereas in the former shape and grid properties are co-ordinated at the level of two reflective and two rotational symmetries, in the latter these properties display no co-ordination.

In figures 2.19, 2.20, 2.21, 2.22, (p. 115), four squares are introduced on a four by four square grid. In all these figures the grid symmetries of S1 are retained. In figure 2.19, (p. 115), all shape symmetries of S1 are also preserved. In figure 2.20, (p. 115), the shape symmetries of S1 are reduced to two reflective symmetries and two rotational symmetries, through 180° and 360° turns. Figure 2.22 retains only the rotational shape symmetries, while figure 2.21 retains none of the shape symmetries of the initial square.

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1 The only symmetry present in this configuration is rotational symmetry through a 360° turn. However, this is a symmetry every shape possesses and is, thus, not taken into consideration.

- **Co-ordinated symmetry breaking and intelligibility**

The examination of these figures shows that symmetry breaking can take two different pathways. One is a *co-ordinated symmetry breaking* in which shape and grid properties might break different symmetries but preserve one or more symmetries that are the same in both layers. The other is a *non co-ordinated symmetry breaking* in which each layer of properties either breaks symmetry completely or breaks a different kind of symmetry.

Thus, in figures 2.11, 2.12, 2.13, 2.14, 2.19, 2.20, 2.22, (p. 115), a co-ordination of shape and grid properties fastens the two layers together. On the other hand, in figures 2.15, 2.16, 2.17, 2.18, 2.21, (p. 115), a lack of co-ordination releases them towards opposite directions. In the former shape and grid properties are firmly interconnected by the same rules. They are, thus, understood as a single system. In the latter they are independent from each other organised by different rules. In this case they are understood as two different systems.

It could be argued that a configuration in which shape and grid properties are linked into a single system creates a single reading. On the other hand, one in which these properties belong to two different systems generate two different readings that are in tension with each other. Therefore, two kinds of intelligibility of formal patterns can be defined. One is based on a single interpretation relying on a gathering of the two levels of properties under the same rules. The other relies on more than one interpretations each of which leads to a different direction.

- **Visual intensification of symmetry**

In the previous chapter it was suggested that formal-geometrical properties operate in two levels. One is the abstract, structural level, while the other one is the concrete, visual level. In a square, for example, the set of eight symmetries form the abstract description. Its contour and four axes capture both the structural and the visual aspects of this description. In this elementary configuration both reflective and rotational symmetry are recognisable. However, reflective symmetry is visually represented by identical defining lines on either side of the four axes. To identify rotational symmetry, though, one needs to imagine or draw on paper the shape under rotation.

In composite shapes which preserve both symmetries like in figures 2.7-2.10, 2.11-2.13, 2.19, 2.20, (p. 115), reflective symmetry is intensified further. This intensification takes place at both abstract and visual levels. At the abstract level it is achieved by a gathering of more than a single element under the co-ordinating role of the axes. At the visual level it is based on a gathering of contours and their extended lines under the role of these axes. On the other hand, rotational symmetry is emphasised only as a structural property. Thus, in these figures the preservation of reflective symmetry stabilises the axes pulling them up to the visual level.

In figure 2.22, (p. 115), the preservation of all four rotational symmetries intensifies rotation. In this case rotational symmetry is more evident than in figures 2.7-2.10, 2.11-2.13, 2.19, 2.20, (p. 115),. On the other hand, the breaking of reflective symmetry undermines the axes of S1. In figures 2.15-2.18, 2.21, (p. 115), the reduction of all shape symmetries weakens both these properties and the axes of the initial square.

In the last figures symmetry seems weaker at both structural and visual levels. At the abstract level it operates only in the layer of grid properties. At the visual level it articulates relationships amongst grid lines that are implicitly present. To reveal the symmetries of a grid that is hidden behind the asymmetrical disposition of shapes, one needs either to imagine the extensions of these lines or to draw them on paper.

*Therefore, the distinction between shape and grid properties allows a study of patterns that possess **approximate or implicit symmetry** emerging through the properties of extended lines.* It also allows an identification of visual, (explicit), and abstract levels of properties, (implicit). The former are visually represented by the contours and the axes of shapes. The latter are disguised behind these contours. *The former are properties that are raised from the structural to the observable level. The latter are properties that are weaker at the observable level. The former are properties that one actually 'sees'. The latter are properties one is 'aware of'.*

The notion of co-ordination of shape and grid properties seem to explain how elements physically absent from a formal pattern like grid lines, geometrical centres or axes become visually identifiable. In the previous chapter it was mentioned that Gestalt psychologists suggest that these elements are forced into place by a perceiving mind that recognises the simplest structure in a visual pattern. *This analysis suggests that it is the structural and visual intensification of symmetry by different layers of properties and by a gathering of physical elements under the co-ordinating role of an axis that makes these elements recognisable.*

It turns out that physical elements play an important role in the ways patterns are understood. This is explored further in the following section.

- **Physical properties**

In the figures examined above regardless of symmetry preservation or symmetry breaking of the pattern as a whole each of the shapes belongs to the configuration and is considered as a closed structural entity[2]. This means each shape is recognised as a square or a rectangle possessing certain symmetries when seen

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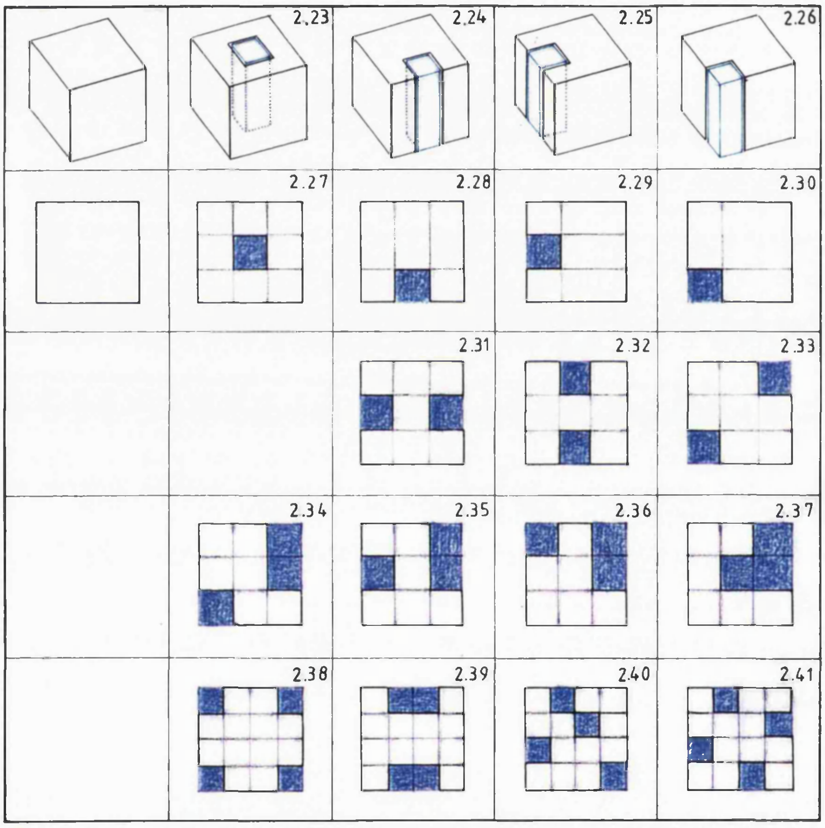
2 Or as a group according to group theory. As it was mentioned in the previous chapter shapes are structural entities and not individual units. However, the term 'element' will be used for these entities to distinguish between the combination of shapes and the shapes themselves.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on its own. If figures 2.1-2.5, (p. 115), are examined in terms of the grid units that belong only to S1, then they are transformed to figures 2.23-2.26.

The description of each of these configurations in terms of symmetry rules that stay invariant is the same with the one provided by looking at figures 2.11-2.14. However, the operation changes from ***superimposition*** to ***subtraction***. Looking at these groups of figures ***superimposition*** could be defined as occurring when a shape is combined with another one in a way that they are both present through an explicit presence of their defining lines. ***Subtraction*** occurs when a shape is taken away from a configuration in a way that both this shape and the initial one are implicitly present through a break in the continuity of their defining lines. In this case there is also a new shape resulting from this operation[3]. A first description can identify a volumetric cube ring in figure 2.23, a volumetric U in figures 2.24, 2.25 and a volumetric L in figure 2.26.

Looking at the horizontal sections through these volumes analysis moves to figures 2.27-2.30. In figure 2.27 a square unit is removed without affecting the contour of S1[4]. In figures 2.28-2.29 both the area and the contour of S1 are changed. However, in figures 2.28, 2.29 the vertexes and three sides of S1 are preserved, whereas in 2.30 one vertex and a part of its two sides are removed. Thus, figures 2.28, 2.29 retain all reflective and rotational symmetries of the four vertexes of the initial square. On the other hand, figure 2.30 preserves reflective symmetry of the back left and right vertexes on the vertical axis and of the back right and front right vertex on the horizontal axis. This shows that *symmetry breaking in these transformations affects three levels of properties: shape, grid and **contour or physical properties.***

The structural information contained in a line can be represented by two points without loosing anything of its description. A defining side of an elementary shape can be, thus, reduced to the points it intersects with two other lines. Similarly an elementary shape can be reduced to its vertexes because even when the lines are removed the description stays the same.

Both vertexes and defining lines of a shape represent these properties at the visual level. If the defining sides of a square are removed its pattern is visually weakened. However, the abstract pattern is still present carrying the description of the shape. On the other hand, if a vertex is removed the description of the square is also removed resulting in a new shape.

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3 An analogy of superimposition with two layers of transparent paper added one at the top of the other and of subtraction with a single layer from which a specific part is cut can clarify the distinction between the two operations further.

4 This is a special case of subtraction which does not affect the lines of the two shapes. However, if the square unit is seen as missing, this configuration qualifies also as resulting from subtraction.

These observations can lead to a better definition of shape and grid properties. Shape properties refer to the symmetries of a set of points belonging to both the area and the periphery of a shape. Grid properties refer to the symmetries of the extended lines of a shape. Finally, physical properties seem to refer to the symmetries of the defining lines and the vertexes of a shape and they are the ones that carry the two other layers of properties into the structural and visual level.

Thus, in figures 2.28 and 2.29, (p. 119), the physical properties preserve the symmetries of the four vertexes of S1. On the other hand, in figure 2.30, (p. 119), they retain the symmetries of three vertexes only. Whereas in the former the square retains its description at the physical level, in the latter it breaks this description by the removal of a vertex. In figures 2.28 and 2.29 S1 is recognisable. On the other hand, in figure 3.30 it is more difficult to reconstruct this shape because one of its vertexes is removed.

- **Co-ordination of shape, grid and physical properties**

In figures 2.28 and 2.29 shape, grid and physical properties are co-ordinated retaining certain symmetries invariant. This co-ordination creates a configuration in which the shape resulting from the transformation, (S1-S2), S1 and S2 are all recognisable as a firm system.

In figure 2.30, (p. 119), only the shape and grid properties are co-ordinated retaining reflective symmetry on the diagonal axis. In this case access to S1 and S2 is constructed only by the shape and grid properties that stay invariant. A tension is, thus, created in which the recognition of S1 and S2 produced by the two co-ordinated levels is contrasted by the decomposition of these shapes at the physical level.

- **Reading formal patterns as transformations**

The retrieval of S1 and S2 in all these figures shows that what is read is not simply the configuration S1-S2 but a transformation, i.e. an operation, certain elements and certain rules that stay invariant. Similarly in figures 2.7-2.10, 2.11-2.14, 2.19, 2.20, (p. 115), a transformation is read that reproduces in reverse order the initial from the composite shape.

The reconstruction of S1 and S2 in figures 2.27-2.30, (p. 119), is based on the reversibility of the process which completes the missing side. The completion of this side transforms these figures into figures 2.7-2.10, (p. 115). Thus, both readings, S1-S2, and S1+S2, are activated showing that superimposition and subtraction are complementary operations. *Thus, reading a configuration is a process in which a transformation is retrieved establishing associations amongst structural entities and operations.*

The individual elements, the rules and the operations are all interconnected into a structure. However, attention seem to shift from one operation to the other as well as from one element to the other. This is because there is reversibility in the system which reconstructs the process. In this respect, all S1, S2, S1-S2, and S1+S2 interact creating a tension amongst various readings.

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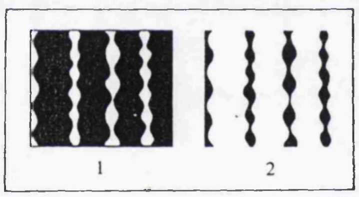


①

Perceptual psychologists have often referred to situations like these as ambiguous situations in which attention shifts from the one element to the other, (illustration 2.1). They see this ambiguity as based *on the capacity of a shape to bound two elements by the internal and the external side of its contour*, (rule of good continuation). Thus, the inner side of the contour of S1-S2 defines a U shape, while its outer side defines S1 and S2.

Arnheim suggests that in these cases a figure-ground phenomenon is created in which complementary shapes assume the role of both figure and ground. He also suggests that when shapes are superimposed on each other a depth phenomenon is constructed in which the shape whose contour is occluded will assume a backward position[5].

*This analysis suggests that what creates the shifts of attention, the figure-ground or the depth situation is not perception which focuses either on the one individual shape or on the other. It seems to be the participation of these shapes into a transformation in which operations are reversible enabling complementary readings*[6].

Thus, a tension amongst readings is created even in configurations which retain certain symmetries invariant at all three layers of properties like in figures 2.27-2.29, (p. 119). However, regardless of this tension the configuration is taken as a single system because of the symmetries that are preserved. Besides, the systematic preservation of reflective symmetry in these figures intensifies the vertical and the horizontal axes raising them to the visual level.

Figures 2.31-2.33, 2.34-2.37, 2.38-2.41, (p. 119), explore subtraction in more complicated arrangements. In figures 2.31, 2.32, 2.39 the preservation of symmetries of the initial square in all layers of properties creates a system in which this element, the removed elements, those elements resulting from subtraction, the operations and the rules are all linked together easing intelligibility and intensifying the preserved axes.

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5 Rudolf Arnheim, 'Art and Visual Perception, A Psychology of the Creative Eye', California University Press, 1974, p. 248.

6 The above figures form a transformation system the structural relations of which are represented on a contour. Thus, this contour represents a structural pattern consisting of both operations, elements S1, S2, S1-S2 and the rules that stay invariant. As it was suggested in the previous chapter perception theories seem to confuse a description with its representation or otherwise confuse a structural pattern with its interpretation. Thus, for these theories the elements S1, S2, S1-S2, S1+S2 were thought as attracting attention rather than the structural pattern.

On the other hand, in figures 2.34-2.37, 2.40, (p. 119), the shape and physical symmetries are broken creating a tension amongst the various levels of properties. In these configurations the elements, the operations and the rules are in a constant tension to each other operating at different directions.

Thus, in figures 2.27-2.29, 2.31, 2.32, 2.39, (p. 119), the tension between one reading and another is resolved by the preservation of symmetry in all layers of properties. This resolved tension in which various readings interact within a single one seems to capture what architectural theory has often defined as *a uniformity and variety*[7].

On the other hand, in figures 2.30, 2.34-2.37, 2.40, (p. 119), this tension is not resolved. This leaves the various layers suspended creating constant shifts from one layer to the other and from one operation to the other. As there is no possibility for these to meet in a common property attention is consumed by these shifts bringing a different one to the foreground. In perceptual psychologists' terms in these configurations there is a increased tension between figure and ground.

To summarise, the above observations show that formal patterns are read as transformations from higher to lower levels of symmetries. What is captured is the ways symmetry at the higher level breaks towards the lower levels. What is also captured is the ways the latter extend beyond themselves generating the former. In this respect, it is suggested that *both elementary and composite configurations can be described as transformations.*

The examination of the above figures also shows that intelligibility of a configuration relies on a reconstruction of its process of genesis. In this reconstruction higher levels of properties can be reached that extend beyond the properties of the given pattern. *Thus, intelligibility relies on a relationship between higher and the lower levels of order based on invariant properties along a transformation.*

A first examination of elementary examples can lead to the suggestion that the more the same principles stay invariant in all layers of properties the more stability is created in a pattern. This stability is about a

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7 William Mitchell suggests that the 'uniformity and variety', or 'unity and variety' or 'order and complexity' has been identified by many theorists as accounting for the aesthetic value of formal systems. Theorists like Francis Hutcheson suggested that 'richly varied compositions that are organised in accordance with some underlying principle are beautiful'. For Mitchell the unity and variety principle applies to classical architecture as well as to modern examples of buildings like Le Corbusier's villa Savoie with its irregular forms within the symmetrical format of an enclosing shape and a structural grid. It also applies to the Constructivists' irregular, asymmetrical and random assemblage of forms showing that there is no universal definition of aesthetic value. There are simply different ways in which people value properties in compositions. W. Mitchell, 'The Logic of Architecture, Design, Computation and Cognision', The MIT Press, 1990, p. 31.

firm interconnection amongst the different layers of properties into a single system. This system tends to be understood at once.

On the other hand, the less the same properties stay invariant in these layers the less they are grasped as a firm structure. In this case shape, grid and physical properties become individuated governed by different rules. They tend to be understood as two different systems that are in a tension with each other.

The analysis of these elementary examples also shows that co-ordination intensifies the representational parameter of symmetry bringing certain axes to the visual level. On the other hand, lack of co-ordination weakens the representational power of the axes and keeps them below this level.

It can be also suggested that two different kinds of intelligibility can be created depending on the ways in which symmetry breaks. In a pattern of co-ordinated symmetry breaking intelligibility relies on a single interpretation. In a non co-ordinated symmetry breaking intelligibility is based on multiple interpretations. In the former intelligibility captures multiple readings embedded into a single one. In the latter it captures multiple readings that interact. In the former attention quickly moves from variety to unity. In the latter attention is endlessly engaged by variety since there is no possibility for diverse readings to meet into the single plane of unity and oneness.

## RECONSTRUCTING A TRANSFORMATION-SETTING THE CRITERIA FOR AN ANALYTICAL APPROACH

As it was suggested the configurations resulting from superimposition or subtraction are understood by their reference to the initial square. *Thus, analysis should proceed from the higher to the lower levels of order examining the properties that stay invariant along a transformation.*

Moving from elementary configurations to buildings and seeing them as transformations or as products of symmetry breaking the question that is raised is :

How lower levels of symmetries of more complex configurations than the ones observed so far, can reconstruct the higher levels? In other words, looking at a building how is it possible to identify higher and lower levels of order, the operations that break them and the properties that stay invariant?

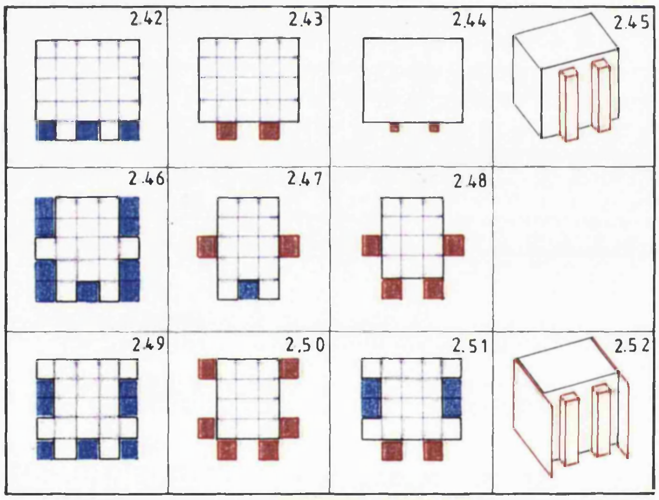
If the figures examined previously are capable of generating ambiguities, complexities and tensions then one would expect that buildings are far more complex arrangements possessing an extensive employment of the above characteristics.

However, even in elementary figures like in figures 2.27-2.29, (p. 119), there can be a number of other readings different from the ones described above. In these figures the difference between S1, S2 and S1-S2, is that whereas the former can refer only to themselves, the latter refer to both higher and lower levels than themselves. Thus, when the lines of the former are extended they never cross the area of the shape. On the other hand when the lines of the latter are extended they cross its area subdividing it into smaller shapes.

In figure 2.28, (p. 119), the operation can be seen as addition of two squares on the front side of a rectangle occupying three by two grid units. Another possible reading is the division of the U into two rectangles occupying one by three grid units at the left and right sides of S1 and one rectangle occupying one by two grid units at the centre of S1.

The rest of the figures could be also subdivided into a number of smaller units and change the ways in which transformation is read. However, transformation by subtraction seems the most economical one. This is because as the examination of figure 2.28, (p. 119), showed two elements have to be attached to a three by two square units rectangle or two lines have to be extended for each of the two alternative readings to be possible. On the other hand, subtraction requires the removal of a single element only.

Besides, the shape properties of these readings are based on a symmetrical distribution of the axes of the smaller squares or rectangles with respect to the vertical axis of S1. This shape structure appears more complicated than the shape structure read through subtraction requiring two new axes for its description. Thus, it would seem that in these configurations the operation of subtraction prevails.




T2.3

In some buildings readings produced by subdivision of the volume into smaller units are intensified by an articulation of the facades, the plans and the roofs. In Botta's house at Viganello for example the roof articulation underlies the extensions of the lines defining the vertical shaft, (illustration 2.2, p. 126). These attempts are seen as aiming at creating levels of complexity that intensify what is previously described as uniformity and variety.

One may explore the question of which transformation prevails further by looking at possible readings in figures 2.42, 2.43. 2.44. In figure 2.42 one may read three square units subtracted from a square. The same configuration can be seen as two square units added on a rectangle consisting of five by four grid units, (figure 2.43). The second reading is more economical because it involves fewer elements into the description.

In figure 2.46 the configuration could be seen as resulting from subtraction of a square unit and four rectangular units from a square. It could be also seen as resulting from the addition of four square units to a rectangle consisting of three by four grid units, (figure 2.48 . A third reading is also possible based on the subtraction of a square unit and the addition of two square units to a rectangle consisting of three by five grid units, (figure 2.47 ). In this case the third reading would also prevail based on fewer elements.

Figure 2.49 could be seen as three square units and two rectangular units subtracted from a square, or as six square units added on a square consisting of three by three grid units, (figure 2.50), or as two square units added and two rectangular units subtracted from a rectangle consisting of five by four grid units, (figure 2.51). The third reading evolves fewer elements and would seem to persist over the two others as more economical.

These figures show that formal patterns generate a certain ambiguity regarding the operations, the elements and the rules that hold them together. A number of readings are included in a configuration showing that formal patterns are complex systems sustaining possibilities for transformations. However, a certain reading persists describing a system in the most economical way.

As it was mentioned in the previous chapter, Gestalt psychologist dealing with ambiguous configurations have suggested that patterns are seen in such a way that the 'resulting structure is as simple as the given conditions permit'[8]. The above considerations would seem to reaffirm this suggestion showing that the most economical description wins over more complicated ones. However, the others are not removed from consideration. Depending on which transformation takes priority in attention, certain invariants are revealed and the readings they specify are captured.

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8 Rudolf Arnheim, ibid. p. 53.

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(2)

- **The effect of scale and physical properties in the identification of a prevailing transformation**

In the above figures the various readings are based on the possibility to identify properties that operate at the scale of a large shape and the smaller scale of the shape produced by transformation. The most economical description depends on the possibility to identify the fewest number of elements and the largest shape that is affected by the transformation. *Therefore, the higher levels of symmetries are identified by a process of abstraction that progresses from the large scale to the small scale properties.*

These observations show that the notion of scale is crucial in intelligibility. Capturing a configuration as a transformation seems to be based on the ability to read scale relations amongst structural entities and distinguish the larger from the smaller ones[9]. *Thus, analysis proceeding from the higher to the lower levels of order should proceed from the largest to the smallest scale.*

The importance scale has in a prevailing transformation is demonstrated further if figure 2.42, (p. 125), is changed to 2.44, (p. 125), by a reduction of the size of the small units. In this case the most economical description, i.e. the addition of two units to a large shape, is intensified further reducing the ambiguity generated by the other descriptions. In the level of three dimensional description there can be further intensification of the prevailing reading. This can be demonstrated by figure 2.45, (p. 125), in which the added components are shorter than the largest volumetric shape.

Another important parameter in the identification of the highest levels of symmetry seems to be the possibility of a large shape to retain the physical definition of as many of its vertexes as possible. In each of the prevailing transformations, (figures 2.43, 2.47 and 2.51, p. 125), the large shape retains the physical definition of its vertexes. On the other hand, in figures 2.42, 2.46, 2.48, 2.49 and 2.50, (p. 125), the largest geometrical shape does not retain physical definition of all vertexes.

The importance of physical definition can be demonstrated also by looking at figure 2.52, (p. 125). This figure results from figure 2.43, (p. 125), if the left and right sides of the rectangle are extended redefining the vertexes of the initial square and restoring its symmetries at the level of physical properties. This makes the reading based on subtraction of three square units from this square stronger because the tendency is to emphasise this square.

*This shows that although there are possibilities for multiple readings in a configuration, the parameters of scale, physical definition and economy of description based on as few elements as possible force*

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9 Configurations can be also characterised by no clear distinctions of scale or no scale distinctions at all like a grid composed of equal grid units. These belong to another category of patterns produced by translation of a square unit along two directions. The ones examined at this place are composed by elements with clear scale distinctions that come together by the operations of subtraction or addition.

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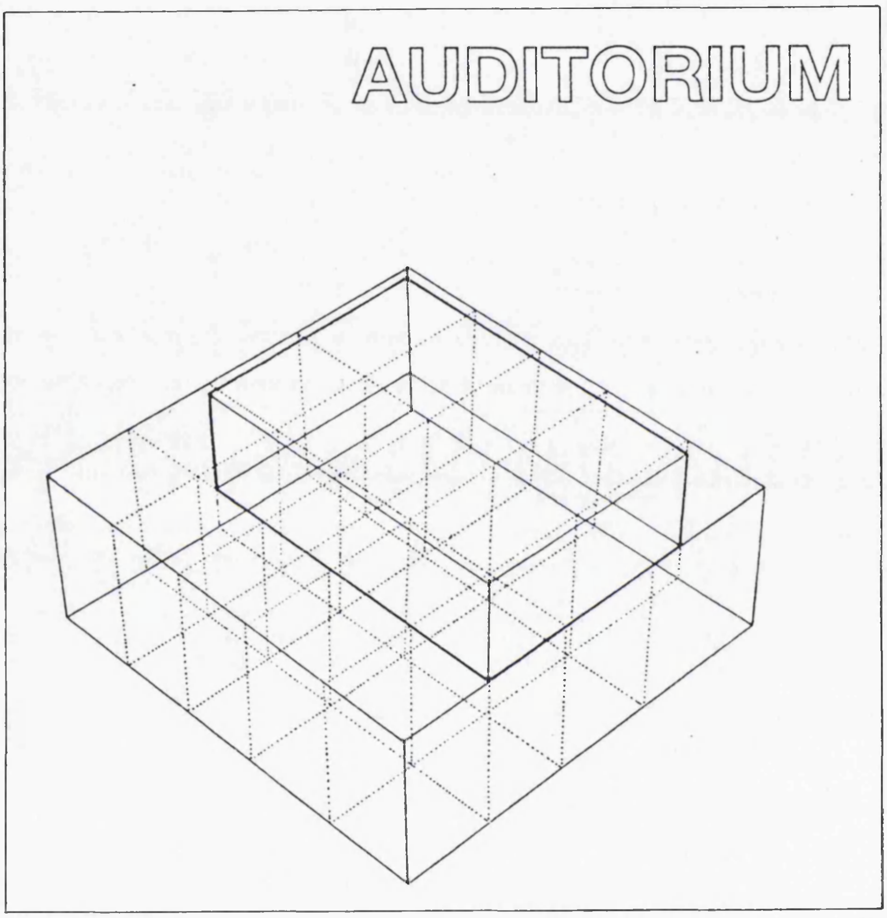


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*readings towards a specific direction.* Analysis, thus, could identify the highest order concept based on the above factors and proceed down to local levels of articulation. The identification of these levels can be also based on these parameters.

- **The notion of intentional symmetry breaking**

The operations described so far are superimposition and subtraction. The examination of figure 2.52 identified another operation also. This is planar extension constructed by the extension of the defining sides of a shape. These operations are also identified by a number of authors in the context of some real buildings. Subtraction has been often described as erosion or excavation of a volume. Baker has suggested that Le Corbusier steps down the slab at Villa Stein and erodes two of its corners[10], (illustration 1.27, p. 45). Zardini has also suggested that Botta's buildings are shaped as 'excavated volumes endowed with true sculptural qualities'[11]. Excavation occurs along the north-south axis intensifying symmetry as a single reading at the level of volume, elevation and plan.

In an analysis of Meier's Atheneum Baker identifies the operation of superimposition suggesting that the architect 'places the closed box of the auditorium' inside a square box that forms the generic state of the building[12], (illustration 2.3). He also identifies planar extension in Le Corbusier's villa Stein where one of the side panels of the eroded slab is extended to restore its missing elements, (illustration 1.27, p. 45).

*The accommodation of a single reading by Botta or of two readings by Le Corbusier, one being about the distorted slab and other about the restored slab, seems to point to an external agency which changes a configurational system to emphasise either a single or many interpretations.* This observation seems to reaffirm what was suggested in the previous chapter: *Composition is an act of intentional symmetry breaking rather than an experimentation in a field of pure possibility.*

The above considerations show that in an analysis of formal properties one cannot simply look at segments of form and their interrelationships. One cannot simply look at all possible readings either. On the contrary, analysis should proceed from the higher to the lower degree of order and from the larger to the smaller scale to examine how possibilities are integrated or eliminated in a transformation based on patterns of symmetry breaking.

As it was suggested before co-ordinated symmetry breaking tends to clarify ambiguities and reduce possibility. A non co-ordinated symmetry breaking tends to encompass possibilities that are often

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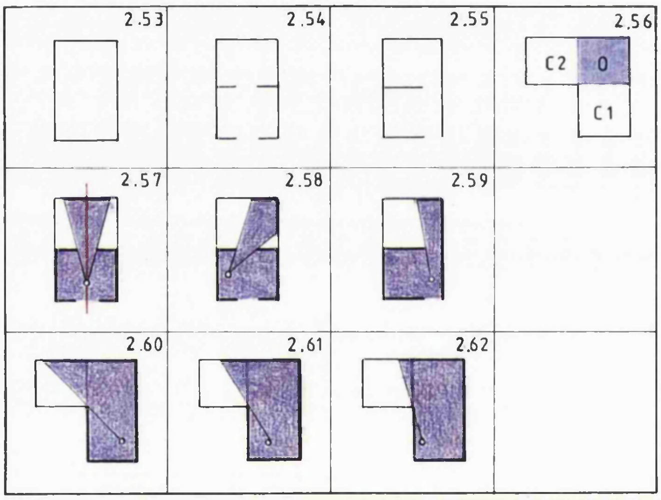
10 Geoffrey Baker, 'Le Corbusier, An Analysis of Form', Van Nostrand Reinold, 1989, p. 172.

11 Mirco Zardini, ibid. p. 71.

12 Geoffrey Baker, 'Design Strategies in Architecture, An Approach to an Analysis of Form', Van Nostrand Reinold, 1989, p. 197.

developing in opposite directions. As it was also suggested the former unites multiple readings under a single reading, whereas the latter juxtaposes them eliminating unity.

Further, an approach based on the above considerations is founded on the notion of composition as an intentional activity in which a creative mind recognises patterns of symmetry breaking and intentionally manipulates them to encompass or eliminate possible readings. Thus, an approach based on invariants along a transformation seems to offer access to the internal operations of composition providing a common tool for analysis and synthesis.




T2.4

## PART TWO

### • SPATIAL PROPERTIES AND THEIR RELATION TO FORMAL PROPERTIES

In this part the discussion moves to a description of configurations seen as spatial patterns and of the ways these are captured by a peripatetic observer. Therefore, instead of looking at layouts as being visible as wholes at once, it looks at them as being experienced gradually where only a certain part is visible at a time.

A discussion of theories carried out in the previous chapter lead to the suggestion that an analysis of spatial patterns can be based on a study of properties that stay invariant as an observer changes his position in space. It was also suggested that formal properties are embedded into the spatial structure in a way that invariant spatial characteristics carry with them invariant formal characteristics. In this context, a study of invariant spatial properties and of their formal characteristics can of these properties can enable an analysis of the ways formal properties enter spatial experience.

To examine this hypothesis, one may begin with elementary layouts and look at how visual information changes or stays constant as the observer alters his position in space. Then one can look at which are the formal parameters of this information that enable an observer to recognise the total set of formal relations in a system.

Figure 2.53 shows a spatial rectangle. In figures 2.54, 2.55 this element is transformed into two spatial rectangles by a dividing surface[13]. Finally, figure 2.56 shows a spatial L. Figure 2.53 is a about a bounded convex space. All corporeal and incorporeal points inside this space are visually interconnected in a way that an observer receives always the same visual information. Thus, he grasps this space at once and recognises it as a spatial rectangle. In figures 2.54, 2.55 the observer sees both spaces simultaneously as wholes only from the door that connects them. Otherwise his visual fields consist of the space he is in and a part of the other space.

As opposed to the layout in figure 2.53 where information is constantly the same, the layouts in figures 2.54, 2.55 transmit different information as an observer moves from one bounded space to the other. Therefore, as layouts become more complex, consisting of more than one bounded convex spaces, visual information ceases to be invariant and changes as a person moves in space. Besides, the more complex

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13 These two layouts were also examined in the introductory section of this thesis to show the ways in which formal properties enter spatial experience in the form of a geometrical axis or of a binding physical element. In this chapter these examples are used again with the scope to extend these observation towards a description of invariant properties picked up during spatial experience.

they become the less they offer instant access to their shape and form and the more movement is required to see them as wholes.

Capturing the shape and form of a layout means to capture the symmetry group of the set of its spatial and physical points. Thus, in the layout described by a single convex space one can understand at once the reflective symmetry of this space on the back to front axis in all three layers of properties, i.e. shape, grid and physical properties.

In the layouts of figures 2.54, 2.55, (p. 129), though, the dividing surface disturbs an immediate understanding of the ways these layers of properties are organised. Similar observations have led Benedict to consider that the description of a layout in terms of its 'real' shape and form can be based on a collection of all possible isovists. However, this study attempts to examine whether there is an underlying geometrical structure in visual patterns that transmits information about the geometrical properties of shape and form rather than how information about this structure is formed by an accumulation of visual fields.

Going back to figure 2.54, (p. 129), the visual fields of an observer standing along the axis connecting the centres of rooms are isosceles triangles defined by his eyes, the doors and the surfaces that block his vision, figure 2.57, (p. 129). The geometrical centres of these triangles lie on the same axis that connects the centres of the rooms. *Every visual field constructed from this axis retains this principle invariant.* On the other hand, from every other point in space the axes of the visual fields change, (figure 2.58, p. 129). These axes are not related to any of the geometrical characteristics of the layout. *Thus, there is a geometrical pattern in visual information that remains invariant as a person moves in space. This pattern coincides with the pattern specifying the geometrical relationship between the spatial rectangles.*

In figure 2.59, (p. 129), the geometrical centres of the triangles of the visual fields do not lie on this axis. However, every triangle is defined by the surface on the right side of the layout that connects both spaces. *Thus, whereas in figure 2.57, (p. 129) the formal property that stays invariant is the axis connecting the geometrical centres of the two rooms, in figure 2.59, (p. 129), it is the binding surface.*

These two examples demonstrate that formal and spatial patterns intersect at the level of two different formal invariants. One is the alignment of the geometrical centres of the rectangles, while the other is the alignment of their defining sides. The former manifests itself in space in an implicit way, whereas the latter in an explicit way through the physical presence of the boundary. The former gives access to the properties of shapes. The latter gives access to the properties of the grid lines as well as of the defining elements of these shapes, i.e. to the physical properties.

*In this respect, visual information relies not on a collection of visual fields but on geometrical and physical invariants in the patterns of visual fields offering implicit or explicit access to a formal pattern.*

In the layouts of figures 2.54, 2.55, (p. 129), visual information changes in relation to the convex space that is not visited and not in relation to the convex space one stands in.*Whereas the visual area of the next space is a fraction of the actual area, the visual area where the vantage point is, coincides with the actual area.* In the previous chapter it was suggested that a description of layouts based on convexity is geometry free editing out both shape and surface properties. However, an elementary layout like the one in figure 2.53, (p. 129), shows that convexity is an important parameter generating visual information about geometrical and corporeal aspects in space that stays invariant regardless of the observer's position. *Thus, convexity is that invariant property in space in which the visual pattern coincides with the formal pattern.*

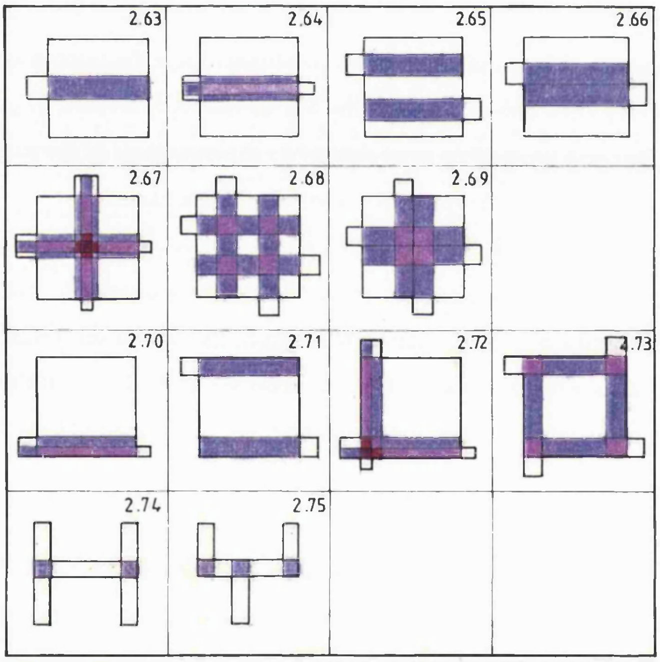
The question that arises, then, is: is there a way in which convexity can allow a description of complex layouts accounting for invariant visual information that offers access to their formal properties? To answer to this question analysis looks at figure 2.56, (p. 129).

In this layout one side of the visual fields constructed from the regions marked as Cl and C2 expands or contracts every time one approaches the left or the right surface, (figures 2.60, 2.61, 2.62, p. 129). *However, from any point of the area defined by the extensions of the surfaces that constitute the vertex, marked as O, one can see the space as a whole at a single glance.*

Thus, whereas from the regions Cl and C2 information constantly changes, from the points situated opposite the vertex it stays the same. While from the former the visual area is a portion of the actual space, in the latter both visual and actual areas coincide. Thus, in this part of space a phenomenon similar to convexity takes place. *Visual information stays invariant covering the actual shape and form of the layout.*

However, although the visual fields constructed from the areas Cl and C2 constantly change, there is an amount of information that remains constant. As radials move depending on one's position, the areas C1+O or C2+O are always visible. Thus, these positions also offer invariant information regarding a portion of the layout. *This portion could be seen as the intersection of all visual fields constructed from every single point in Cl and C2.*

It turns out that spaces C1+O and C2+O seen individually create also a phenomenon similar to convexity offering instant access to every single point within their physical periphery and space. This is because each of these spaces is a convex space operating in a manner similar to figure 2.53, (p. 129),. Seen together, these convex spaces overlap at O which provides visual information about the arrangement as a whole. *Thus, in this layout* ***overlapping convexity*** *is what offers simultaneous access to the spatial and the formal pattern.*




T2.5

The questions that arise at this point are: is it possible to define a research methodology based on the ***overlapping space modelling?***. Is it possible to extend this technique that draws the intersections of convex spatial elements on a plan to more complex layouts? Can the overlapping elements, defining the integration of visual fields produced from different convex spaces, account for the ways spatial layouts offer access to formal properties?

- **Overlapping convexity in more complex layouts - Centralised and dispersed visual information**

To see whether the notion of overlapping space modelling can be applied to more complex examples, one may begin by a rectangle, (Cl), and transform it into overlapping spaces. In figure 2.63 a spatial rectangle, is attached to Cl. If the lines defining this element are extended a new convex space is defined, (C2). This space intersects with Cl resulting in an overlap unit, (Cl,2). In figure 2.65 two spatial rectangles, (C2 and C3), are attached to Cl, in such a way that each of the convex spaces resulting from the extensions of their lines overlaps with Cl constructing two overlap units, (Cl,2, Cl,3). In figure 2.64 C2 and C3 overlap with Cl as well as with each other. The overlap units generated by these intersections are marked as Cl,2, Cl,3, and Cl,2,3.

Starting with the formal properties of these layouts, it turns out that transformation in preserves the reflective symmetry of the initial rectangle bringing the attached shapes and their grid lines under the co-ordinating role of the left to right axis. The examination of the spatial properties looks at the patterns of interconnections amongst convex spaces by assigning a different colour to the overlap units according to the numbers of spaces to which these units belong. The more spaces are seen from an overlap unit the darkest its colour is. The dark-light distinction in the purple hues used to represent overlap amongst convex spaces indicates the distinction between units belonging to a large number of convex spaces and units belonging to fewer ones.

In figure 2.64 all three spaces can be seen simultaneously from Cl,2,3. The layout is figure 2.65 can offer simultaneous information about Cl and C2 or Cl and C3. In this case one has to move from Cl,2 to Cl, 3 in order to see the spatial configuration as a whole. In figure 2.66 C3 shares with C2 a defining side. Although overlap is not constructed between these spaces, the common line offers visual access to both. One sees all three spaces just by moving to the top or the bottom side of C2 or C3. *Therefore, where overlap units share a defining line simultaneous information is also possible.*

The layouts of these figures can be elaborated further if convex spaces are added overlapping with the existing ones along the other direction, figures 2.67, 2.68, 2.69. In figure 2.67 two convex elements are introduced, C4 and C5, in a way that they overlap with all other spaces as well as with each other. The shapes attached to Cl and their defining lines preserve the reflective symmetry of this shape on the back to front axis.

The distribution of colour in this layout fades in a cross-shaped pattern from the centre to the edges. The highest amount of information is provided from the central overlap unit, C1,2,3,4,5. The lowest amount of information is offered from the edges of the layout, i.e. from the white areas at the corners of C1 C2, C3, and C4.

In figure 2.68, (p. 132), there is not a distinction between a single dark area and lighter ones. There are four dark overlap units each of which is surrounded by four lighter ones. In figure 2.69, (p. 132), each of the four dark overlap units shares two sides with each other and two sides with a lighter unit.

Thus, figure 2.67, (p. 132), centralises global scale information in a single unit. Figure 2.68 offers less global information and distributes it according to a chequerboard pattern of overlap units. Finally, figure 2.69, (p. 132), gathers overlap units together eliminating the distances between both dark and light areas. Maximum visual information is offered from the crossed lines at the centre each of which defines a side of two dark overlap units.

In the layouts examined so far the overlap units are distributed in a way that the darkest ones are situated at the centre of a large convex space, (C1). Moving away from the centre there is less visual access to the layout as a whole. In figures 2.70-2.73, (p. 132), the overlap units are located along the periphery of C1. In the previous figures small steps from one overlap unit to the other are enough to receive information. In these figures one has to move from one side of C1 to the other to see the smaller spaces attached to this space. In these cases information is distributed at the edges of C1 requiring an exploration based on movement.

Another important difference between the layouts examined previously and these ones is that in the former convex spaces and overlap units are defined by extensions of surfaces, whereas in the latter they become increasingly defined by surfaces themselves. This is because each of the minor convex spaces shares a defining surface with the large space in the middle. This kind of peripheral information in which there is a physical definition of convex spaces and overlap units puts emphasis on the binding surfaces as integrating devices rather than on the centre of a layout.

One may begin to observe even more dispersed patterns of visual information by looking at figures 2.74, 2.75, (p. 132). In these configurations a linear convex space overlaps with smaller ones in a way in which overlap units are distant from each other. This linear extension of a space together with the dispersed pattern of distribution of overlap units intensifies movement.

To summarise, two different kinds of visual information provided in a layout are identified. One is a centralised pattern of information transmission in which the spatial system is immediately seen from few points of view, while the other one is a dispersed pattern of information transmission that requires movement and exploration.

However, in the layouts examined so far regardless of the degree to which visual information about the layout as a whole is concentrated on a single position or distributed in a number of positions, the formal principles seem to be exposed in spatial experience. This is because all layouts consist of a large space to which smaller spaces are attached and open directly.

In figures 2.64 and 2.67, (p. 132), receiving global scale information from the centre of the layout, one can grasp the ways the physical elements are grouped into large and smaller spaces under the co-ordinating role of the two axes. In figures 2.65, 2.68, and 2.68, (p. 132), the distribution of information follows the rhythmical spacing of the grid bays. Thus, the symmetrical distribution of these bays is captured during spatial experience. Even in figures 2.74, 2.75, (p. 132), where movement is required to acquire a complete picture of the layout as a whole, the rhythmical distribution of overlap units displays the rhythmical distribution of the spatial rectangles attached to the main space. In other words, visual information is geometrically determined following the geometrical patterns of the formal structure.

- **Overlapping convexity and its significance**

*The analysis of elementary layouts based on the overlap space modelling shows that overlapping convexity is that condition in which spatial properties and their formal, (physical, geometrical), characteristics stay invariant articulating access to the formal properties of a layout.*

In the previous chapter the notion of the isovist fields as developed by Benedict was discussed as an attempt to describe spatial experience. Isovists define visual fields as the visible areas consisting of the physical elements that are visually accessible from a specific point and the radials connecting this point with the edges of surfaces. These radials change following the changes in the vantage points. Overlapping convex spaces exclude radials from the description concentrating on what stays always constant in the fields of vision. *Therefore, as opposed to isovists that capture spatial experience as a collection of changing visual fields, overlapping convexity describes experience as a structure of these fields.*

Another crucial dimension of overlapping convexity is that it captures the exposure of surfaces defining convex spaces as well as the underlying network of grid lines that establish interconnections amongst these surfaces. This is because it is generated by the extensions of the lines defining surfaces accounting for the ways in which shape, grid and physical properties are observed during spatial experience.

In the review of analytic methods Hillier's and Hanson's notion of convex break up was also discussed as a tool enabling an analytic representation of two dimensional properties of layouts. A convex map subdivides a layout into the fewest and fattest convex spaces by drawing the shortest lines that connect the edges of surfaces with an opposite surface. Analytic measurements developed by these authors like integration and segregation capture the structural properties amongst these convex spaces. However, the difficulty inherent in the convex break up is that first it represents a layout as a set of itemised convex spaces, and second it edits surfaces out of its description. On the other hand, overlapping convex space modelling represents it as a set of relations amongst convex spaces taking also into consideration their defining elements. In this way, a single analytical tool describes the visibility field, the physical definition of this field by boundary walls and their formal skeleton.

*Thus, overlapping convexity brings aspects of the spatial and formal structure into the descriptive level of representation.* It also creates a link between the above and composition. This is because it is generated by configurational elements designers use like shapes, surfaces and the grid lines defined by their extensions. *Therefore, overlapping convexity is about an homology between configurational tools used in analysis and compositional tools used in design.*

To summarise the significance of overlapping convexity lies in the following:

- *It is characterised by a descriptive economy. It overcomes the need to itemise first each visual field, second each convex space and third each geometrical parameter in the visual and in the formal-geometrical level.*
- *It brings notions that designers intuitively use into the realm of analytic representation.*
- *It brings the formal-geometrical characteristics into the level of analytic representation and into the level of properties observed during spatial experience.*

An important dimension of this notion lies also in the fact that it arrives at a clearer definition of convexity. Convexity as defined by Hillier and Hanson is a property of that space any two points of which can be connected by a line that also belongs to this space[14]. As the examination of figures 2.60-2.62, (p. 129), showed convexity is what stays invariant in the expansion and contraction of visual fields constructed from a series of spatial points. *A convex space, therefore, is a structural parameter of visual fields rather than a single entity.*

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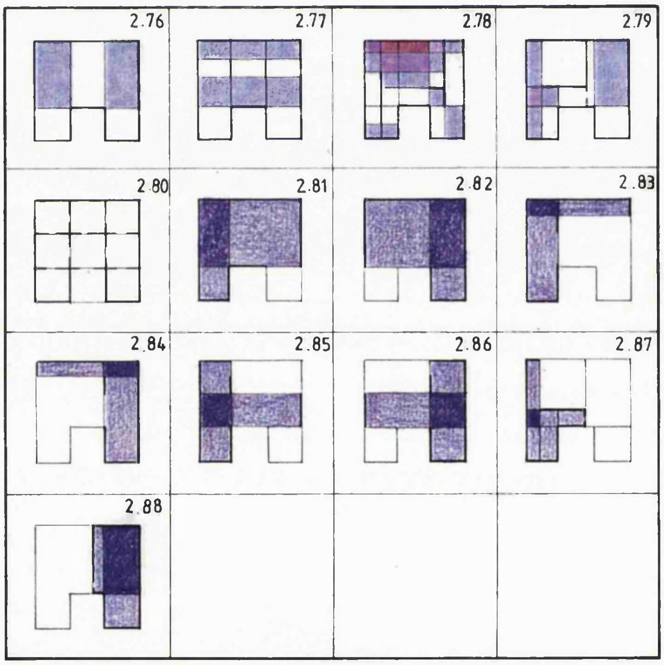
14 B. Hillier, J. Hanson, 'The Social Logic of Space', Cambridge University Press, 1984p. 98.

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- **Extending the overlap space modelling into the analysis of some other examples**

The figures examined before are about layouts in which a single large space is connected with a number of ancillary spaces. These spaces open up directly to the large one without any internal subdivisions. These figures can be thought as characterising the design of a church layout. Churches regardless of stylistic differences create a unification of all spaces of the interior into a single spatial enclosure. There is often an uninterrupted extension of convex spaces in a way that multiple layers of overlap are constructed situated on a large space, (illustration 2.4, page 137).

Physical elements of the interior like pilasters, walls and columns are often placed in a such a way as to provide physical definition to the convex spaces and to the overlapping units resulting from their intersection. The placement of these elements on crucial spatial and geometrical points demonstrates that there is a tendency to bring the global and the local levels of scale articulation under the co-ordinating role of the cross axes[15].

However, layouts rarely have this property of a unified interior space. A set of surfaces subdividing the interior into smaller spaces obstructs the simultaneous exposure of these spaces. To examine the ways the lower levels of articulation distributing surfaces in the interior of layouts interact with the higher levels of articulation analysis examines a series of transformations altering the interior of a layout displayed in figure 2.76.

In figure 2.77 each of the two inner surfaces are placed on the extension of lines defining C2 in a way that the reflective symmetry of Cl on the vertical axis is preserved. In figure 2.78 the inner surfaces are not symmetrically distributed with respect to this axis. However, the grid lines generated by the extension of these surfaces preserve the reflective symmetry of the initial arrangement. In figure 2.79 neither the surfaces of the interior nor their defining lines preserve the symmetry of the initial configuration. Finally, in figure 2.80 both shape and grid properties of the spatial enclosures defined by the new surfaces are retained.

In figure 2.76 there are two overlap units each of which is situated at the back left or right corner of the layout. There is no single position from which this layout is visible as a whole. However, an observer moving from the right side of the overlap unit at the left corner to the left side of the overlap unit at the right corner can quickly build a picture about the layout as a whole.

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15 The overall shape of a building as this is defined by the symmetry group of its outer physical elements seems to refer to the higher levels of scale articulation. Relations specifying the external and internal modelling of its boundary as well as of its interior refer to lower levels of articulation. In figures 2.54 and 2.55, (p. 129), for example, the higher level of articulation seems to be carried by the outer surface, while the lower ones by the inner surface that subdivides the spatial rectangle into two spatial enclosures.

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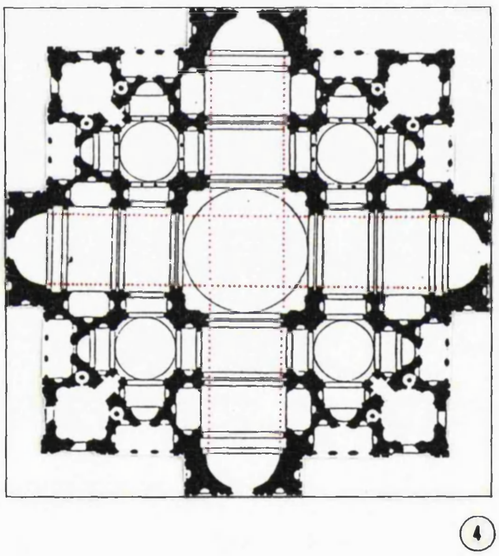

The visual fields constructed from any spatial point in these units offer access to the whole length of two of the defining surfaces of C1 and C2, figure 2.81, 2.82, (p. 136), They also offer access to the extension of one or two of the surfaces of C2. Thus, these surfaces and their extensions are invariant characteristics of every visual field produced from these units.

Besides, the visual fields constructed from these units are symmetrical with respect to the back to front axis. In this respect, the transformation of visual information retains invariant geometrical characteristics in the form of visual fields produced from different positions that are symmetrical to each other.

Therefore, the physical and geometrical characteristics that remain invariant in the transformation of visual information coincide with the shape, the grid and the physical characteristics of formal articulation as these are described in the first section. *This coincidence between the set of formal properties and the set of formal properties observed during spatial experience seems to enable one to link what is experienced sequentially and locally to the total formal organisation of the system. In other words, it seems to bring formal properties directly into the level of spatial experience.*

An examination of figure 2.77, (p. 136), can lead to similar observations. This layout can be seen as a whole from the left and the right defining sides of the overlap units situated at the back and the central left and right sides of the composition. Thus, a complete picture is quickly built by moving from the right defining side of the units situated at the left of the plan to the left defining side of those situated at its right side.

From each of the overlap units at the back left and right corners of the layout two outer surfaces, one surface of C1 and one of the inner surfaces are fully visible, figures 2.83, 2.84, (p. 136). Moving from these overlap units to the ones situated at the centre of the left and right sides of the layout visual contact with the left or the right outer surface, one of the surfaces of C1 and one of the inner surfaces is constantly retained, figures, 2.85, 2.86, (p. 136).

This is because each of the two pairs of overlap units situated on either of the two sides of the layout belong to a single convex space stretching throughout the width of the plan. According to the definition of convexity every spatial point in these convex spaces offers constant access to every other spatial and physical point of it. Thus, although there is no position to stand and observe the physical properties of the configuration as a whole, there are certain parameters of this configuration that remain invariant in the transformation of visual information.

Besides, the overlap units are symmetrically distributed with respect to the back to front axis. This results in symmetrical visual fields constructed from symmetrical positions, figures 2.83-2.84, 2.85-2.86, (p. 136). These fields expose the geometrical co-ordination of all spatial and physical points by this axis. Similarly to the layout examined before, certain invariant formal characteristics picked up during spatial experience seem to allow access to the formal properties of the layout.

In figure 2.79, (p. 136), the spatial enclosures obstruct the extensions of convex spaces beyond their defining boundaries. Thus, there is no point in this layout that offers access to the outer and the inner surfaces beyond the scale of a bounded convex space. However, as it was suggested before, visual fields constructed from the geometrical axes connecting the geometrical centres of the rooms are symmetrical on these axes. Besides, visual fields produced from rooms that are symmetrical on the BF axis are also symmetrical.

In this respect, visual information displays geometrical invariance in the sense of constant shape geometrical characteristics observed from different spatial positions. On the other hand, invariance at the level of the grid and the level of physical properties is limited to the scale of a single room. The co-ordination of the outer and the inner surfaces as well as of their grid lines on the back to front axis cannot be easily detected. This is because these elements do not become invariant characteristics of a large number of visual fields produced from different locations.

In the layout in figure 2.79, (p. 136), the dispersed pattern of distribution of overlap units shows that movement is required to build a complete picture of the interior. Unlike figures 2.76, 2.77, (p. 136), where a small scale movement exposes the interior as a whole, this layout can be learnt by an exploration that covers it from left to right. The left and right outer surfaces can be observed as wholes from the overlap units situated at these positions.

However, unlike the layouts in figures 2.76, 2.77, (p. 136), where every visual field shares common surfaces with every other visual field, (figures 2.81, 2.82, 2.83-2.86, p. 136), in these layouts there are visual fields that are completely different from each other in terms of their physical constitution by surfaces, (figures 2.87, 2.88, p. 136). Besides, there is no geometrical co-ordination of visual information on the back to front axis. Therefore, it is not possible to capture the ways, the outer surfaces and the surfaces of C1 group themselves into shapes and grid lines co-ordinated by this axis. As opposed to the layouts examined previously which expose the total set of formal principles, this layout exposes only local properties of these principles in the form of some external surfaces that are seen in full length.

The examination of the above examples shows that formal and spatial properties can either take similar directions or opposite ones. In the first case the shape, grid and physical characteristics of spatial properties coincide with the shape, grid and physical characteristics of the formal properties. In the second case there is less coincidence operating at the level of the local scale articulation.

This examination also shows that the coincidence between the two layers of structure seems to be based on invariant global scale characteristics built in the structure of visual information. In other words, the analysis of elementary examples of layouts seems to reconfirm the hypothesis put forward in the previous chapter, i.e. it is through a study of the invariant properties observed during spatial experience that an analysis of the relationship between the formal and the spatial properties can be approached.

Thus, visual information is geometrically determined so that it consists of variant and invariant geometrical properties. As one moves in a layout certain properties change while other remain invariant. The notion of convexity and overlapping convexity captures what stays invariant allowing a study of the ways the geometrical properties interfere guiding intelligibility.

## • SUMMARY AND CONCLUSIONS

### • DESCRIBING THE GENERAL FRAMEWORK OF THE RESEARCH METHOD

The examination of elementary configurations carried out in this chapter reached certain suggestions regarding the ways an analytical framework to the problem of the relationship between the formal and the spatial structure can be established. These are the following:

- Formal and spatial properties should be distinguished and examined separately from each other.
- Both levels of structure are examined as systems of properties that remain invariant in a transformation.
- Analysis progresses in stages identifying higher and lower levels of articulation. These levels are about invariant properties connecting the various stages through certain operations. The properties, the higher and the lower levels, the elements and the operations are linked into a firm structure which is the transformation itself.
- Transformation recaptures a genesis of form and space from the abstract higher levels to the specific lower levels of articulation, from the volume to the plan and from the external to the internal appearance of the house.
- This genesis does not refer to the temporal sequence in which composition was developed. An architect might start from a higher order concept like a cube and move immediately to a small detail of its internal or external structuring. Then he might progress in reverse order to define higher levels of articulation. His process might oscillate from the large to the small scale creating constant readjustments until it reaches a desired effect. In other words, there is a difference between the design levels as articulated by the architect and the analytic stages as identified by this analysis. Each analytic stage captures the structural parameters linking levels of articulation rather than an actual design stage.

However, although analysis does not reconstruct the design process, it allows a study of the dynamics of this process. This is because it investigates the possibilities preferred by the designer, the criteria for his selection and the degree to which higher or lower levels of articulation govern this selection. The more the lower levels preserve the properties of the higher ones the more selection is determined by the latter. The less they preserve these properties the more selection is independent of the higher levels and possibilities are more open.

- The identification of analytic stages is based on specific criteria. These are the following: scale, physical definition of the defining sides and vertexes of elements and economy of description.

Thus, the first stage of the analysis is identified as capturing the largest shape concept the physical identity of which is underlined by the physical presence of its defining sides and corners. The following stages are defined through the most economical description that links smaller scale elements of an identifiable physical coherence to the previous stages through some operation.

- In the level of formal description analysis distinguishes between shape, grid and physical properties and looks at the ways they relate to each other. A first hypothesis put forward by this chapter is that the more the properties of these layers coincide the more a single reading is constructed. On the other hand, the more they develop independently of one another the more multiple readings are generates.

- In the level of spatial description analysis of spatial properties and of the ways they relate to formal properties is based on a study of the patterns that stay invariant in the transformation of visual information produced by an observer's movement in space. This study is possible through the overlapping convex space modelling. This is a technique that brings spatial and formal properties into the representational level constructing an homology between design and analytical tools. The patterns of overlap can be observed to see the variants and invariants in the transformation of visual information.

  The hypothesis formulated in this stage is : The more convex spaces overlap with each other the more invariant spatial and formal characteristics are observed during spatial experience, i.e. the more coincidence is constructed between the two levels of properties. On the other hand, the less convex spaces overlap the less visual information retains invariant characteristics, i.e. the less the two levels of structure coincide. A coincidence between the two structural levels raises the formal properties into the level of observable properties. A lack of coincidence does not allow the formal properties to be deciphered during spatial experience.

## • DESCRIBING THE STRUCTURE OF THE ANALYSIS

The above suggestions lead to specific guidelines for the establishment of a research method for tackling the research problem. They also lead to specific strategies regarding the ways this research organises its material in separate sections. These are the following:

- Analysis progresses from a description of formal properties to a description of spatial properties.
- It proceeds from the global to the local scale starting with the external articulation of buildings and moving to their internal articulation.
- Analysis of the external articulation proceeds from the abstract-generic to the specific form focusing on formal properties that organise the houses as seen from the outside, (chapter three).
- The internal articulation is studied from two points of view. One is in relation to formal properties represented on a plan, (chapter four). The other one is in terms of spatial properties and their formal characteristics as these are experienced by a peripatetic observer, (chapter five). Analysis proceeds also in stages starting from the last stage of the volumetric analysis and progressing to lower levels of articulation established by the subdivision of the interior space by inner surfaces.

The reason for which the last stage of volumetric analysis becomes the first stage of the analysis of the interior is based on the fact that properties are studied from the global to the local scale. In this respect, the external volumetric organisation refers to design decisions taken at a higher level of articulation. In contrast, the internal organisation concerns with lower levels of articulation. This is because the former determines the outer boundary of a building, its overall form and shape. The latter determines the interior spaces that regardless of how much they influence the design of this boundary they are elements of less global significance.

It should be noted that analysis of the formal properties of the external appearance of buildings focuses on an analysis of the volumetric structure as a whole rather than on an examination of elevations. The study of elevations is an important parameter in the study of the external articulation of a building. However, a volumetric analysis provides all the information that is essential to understand the ways in which each of the sides of a volume is articulated.

It has been pointed out in chapter one that modern architects seem to arrive at a configuration of elevations through a modelling of the volume as a whole. Local systems of articulation like the individual faces of this volume are affected by decisions taken in relation to a large volumetric scale. As such, elevations should be seen as products of an overall design logic that in many cases is more important than themselves.

It should be also noted that formal description of the interior focuses on properties represented on plans rather than on sections. Sections play a crucial role in representing vertical spatial relationships. However, the primary purpose of this analysis is to study the ways spatial links allow one to overcome the fragmentation of space into individual spatial episodes and perceive the overall organisation of space by formal principles. Vertical links are usually less than the ones operating in the horizontal direction. No matter how extensively they are used, each floor is seen as separate from the others. A study of sections would seem to reach the trivial suggestion that a considerable amount of separation amongst floors through dividing layers does not allow one to see these floors simultaneously. However, reference to vertical connections will be made whenever these are seen as contributing to the observations raised by an analysis of the horizontal organisation of space.

Within this analytical framework the research progresses to the analysis of the formal properties of the volumetric articulation of the selected buildings of Botta and Le Corbusier.

# Part Two

# ANALYSIS

# Chapter Three

# VOLUMETRIC ANALYSIS

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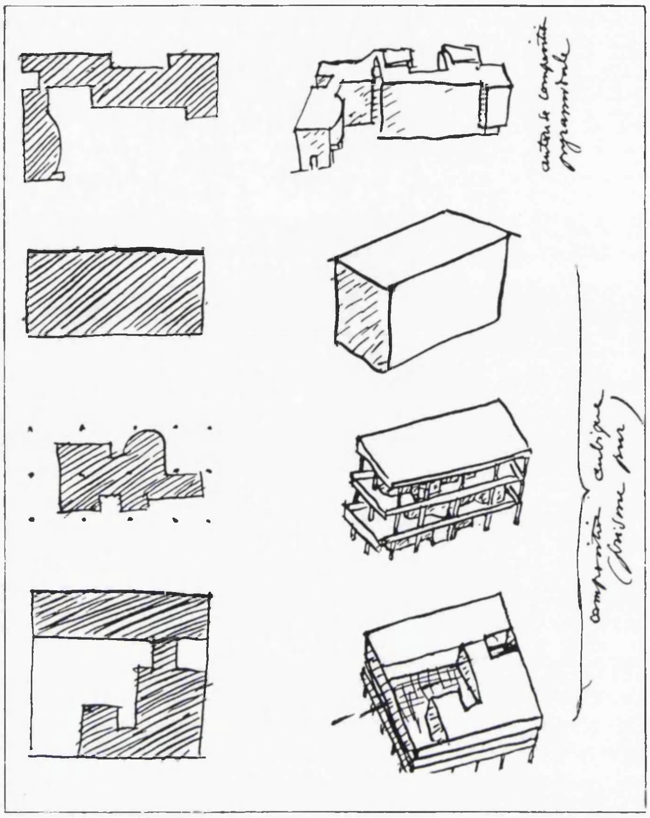

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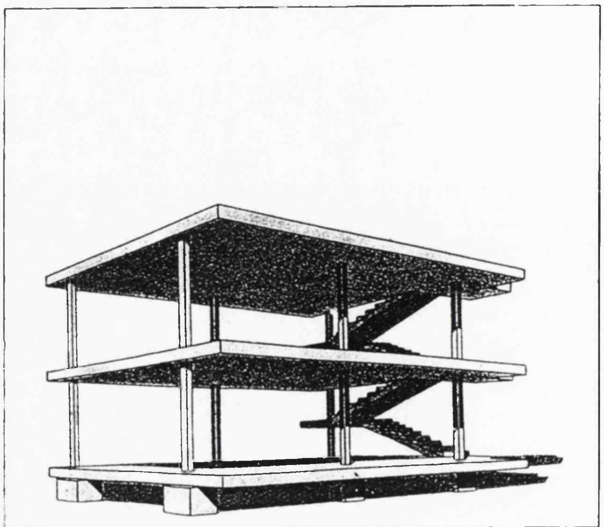

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## INTRODUCTION

- **How buildings are understood from the outside**

A building is seen from the outside as an arrangement of volumes and masses into a three dimensional form. In some buildings this form can be easily defined through some simple geometrical concept, something like a cube or a cylinder. In some buildings, though, it seems difficult to arrive at such a simple description. Botta's houses are often described as simple shapes. In contrast, Le Corbusier's villas with their complex articulations of volumes and planes have often puzzled critics in their attempt to arrive at an identification of their overall form. If surface descriptions like geometrical shapes are used, then Botta's buildings are reduced to a single geometrical notion. In the case of Le Corbusier things seem even worse. His buildings look as amorphous agglomerations of elements.

This chapter starts by addressing the question: *How are buildings are understood as three dimensional formal arrangements from the outside? i.e. is there something in the ways volumes and masses come together that plays a crucial role in the ways they become intelligible?*

The aims of this chapter are threefold:

- Firstly, to answer the question set above, i.e. How these buildings are intelligible as three dimensional systems of formal properties.
- Secondly, to test the hypothesis formulated in the previous two chapters, i.e. Is is possible to examine formal organisation through an analytical framework that looks at formal properties as groups of transformation?
- Thirdly, to extend the analytical model, developed in the previous chapter, from elementary configurations to more complex ones presented by the buildings selected by this research.

- **Formulating a hypothesis - a first description of similarities and differences**

Although surface descriptions cannot provide full answers to the questions raised by this chapter, they can contribute to some initial observations and lead to some hypothesis regarding the subject of inquiry: how these buildings are intelligible from the outside. In what follows a first description of similarities and differences is offered with a view to form this hypothesis.

- **Similarities and differences in the physical articulation of the volumes**

A first description of the villas of Le Corbusier could be illuminated by his drawing of the 'four compositions', (illustration 3.1). By these figures Le Corbusier offers a classification of principles used in his designs in two and three dimensions. In the first two sketches he distinguishes between a complex concave shape and a simple convex shape. In the last two figures he combines both concave and convex shapes. The convex shape defines the outer boundary of the arrangement. It is a simple solid element that

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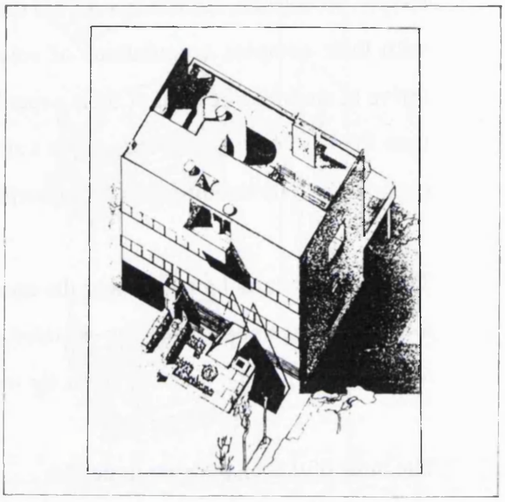

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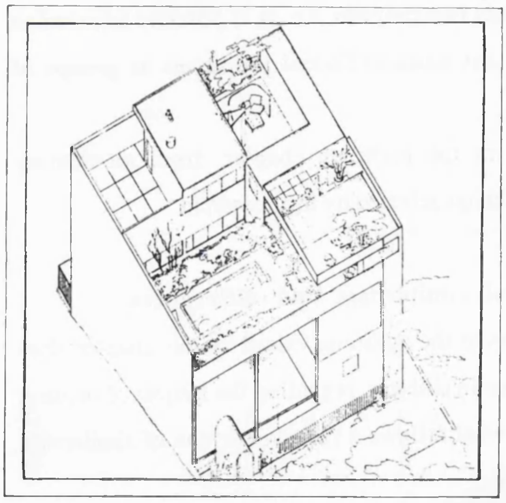

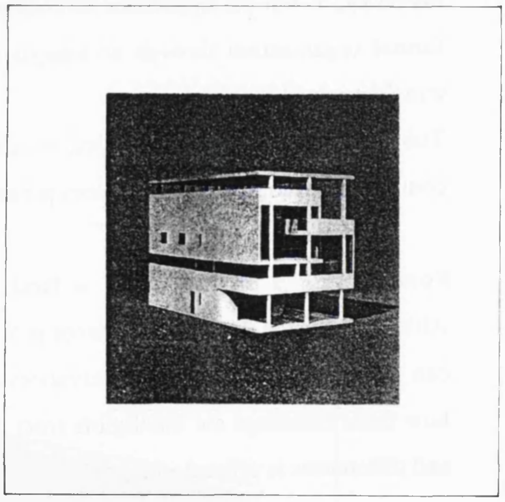

is excavated to define a concave shape within its volume[1]. A sculptural articulation of the block seems to be the main objective of this combination. The sample of buildings used by this research study falls into the last category, (illustrations, 3.3-3.6). In all these houses single blocks are hollowed out to accommodate open spaces contained within the perimeter of the volume.

Botta has not offered such a categorisation of his design principles. However, a first observation of his four buildings could identify some similarities between the two architects regarding the shapes of the volumes they use and some of the ways they treat these volumes, (illustrations 3.7-3.9, p. 147). Like Le Corbusier, Botta sculptures simple solids to create terraces. Sculpturing occurs at the centre of the volume defining one or more vertical shafts that open towards the outside.

Going back to Le Corbusier and examining the horizontal division of his houses the classical paradigm of horizontal layer stratification reveals itself. For Colin Rowe, Le Corbusier's villa Stein and Palladio's villa Malcontenta regardless of variations in ground, first floor and roof treatment, comprise a base, a 'piano nobile' and a roof termination[2]. The same tripartite horizontal division exists in villa Savoie where the pilotis, the first floor and the roof structure evokes the podium - 'piano nobile' - pitched roof horizontal division of the Palladian villas, (illustration 3.3). Villa Meyer and villa Baizeau have a similar horizontal organisation allowing also for variations in the ways the horizontal layers are articulated[3], (illustration 3.5-3.6). This tripartite division of the volumes expresses an horizontal stratification of programmatic elements in three different layers: entry at ground floor, day activities at the first floor and bedrooms at the second floor and the floors above.

Botta divides also his houses into three horizontal layers. Like Le Corbusier, he uses horizontal division to represent the entry, the public and the private activities. However, although both architects conceive their volumes as single blocks and in spite of the excavation tendencies and the tripartite horizontal layering, they handle the blocks, the excavated parts and the horizontal division in fundamentally different ways.

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1 The difference between the third and the fourth case is that while the former articulates a contrast between an irregular concave shape and a regular grid of columns and slabs, the latter articulates a contrast between an irregular concave shape and a regular convex shape that surrounds it. However, both compositions express the main concern of Le Corbusier for a freely disposed wall system inside a simple box.

2 C. Rowe, ' The Mathematics of the Ideal Villa and other Essays', The MIT Press, Cambridge, Massachusetts and London, 1982, p. 7.

3 Villa Meyer replaces the exposed structural grid of the ground floor by a solid base and has both horizontal and vertical planes at the top. On the other hand, Villa Baizeau exemplifies the pilotis, while for the crowning it substitutes the vertical curved planes of villa Savoie for a straight horizontal plane.

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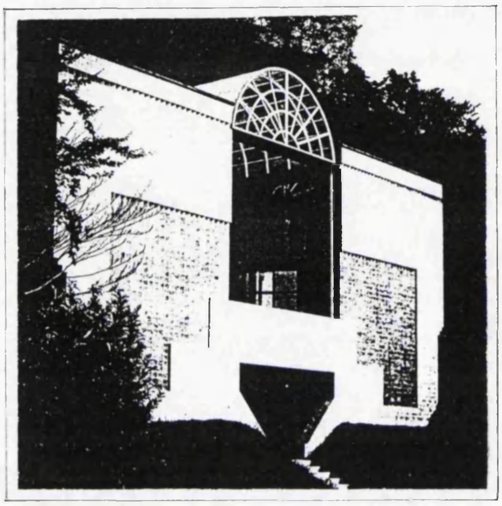

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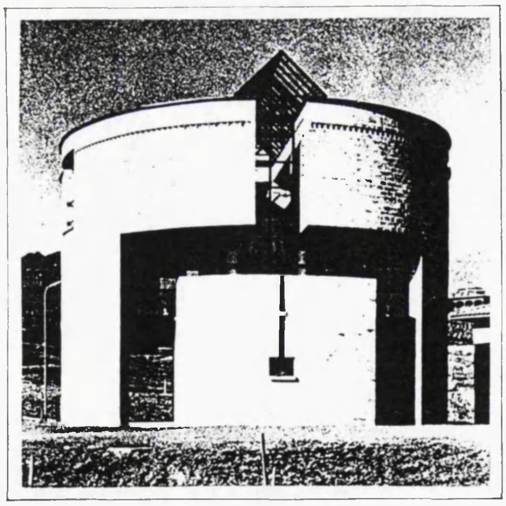

For Le Corbusier the *Do-mino Structure*[4] abolishes the structural necessity of load baring walls, (illustration 3.2, p. 145). These walls are used by Botta rooting his buildings to ground. Thus, whereas the *pilotis* elevates Le Corbusier's villas, Botta's house sit heavily on the ground. Whereas the pilotis unifies the landscape and the ground floor, the load bearing walls of Botta have to be pierced to allow for continuity between the inside and the outside space.

Le Corbusier sees the do-mino structure as a structural solution as well as as an expressive device. The concrete frame offers him the morphological freedom to decompose the simple volumetric form of his houses into a set of vertical support elements and horizontal planes. In the third sketch of his four compositions, (illustration 3.1, p. 145), he shows how cubic forms can be articulated when combined with columns and slabs. Further, he makes maximum use of this freedom giving planar readings to both slabs and facades. The morphological potentials of the structural system are summarised by his 'five points'[5]. The 'free facade', the 'pilotis', the 'roof garden', the 'free plan' and the 'ribbon window' refer to the disconnection between the various systems of his buildings and to the decomposition of these buildings into distinct elements.

As opposed to Le Corbusier who analyses his volumes into columns and planes, Botta strives for the most solid, volumetric appearance his cubic forms can have. The traditional load bearing system requires thick walls that extend uninterruptedly from the top to the ground level. The substitution of the repetitive traditional openings for a single central aperture creates massive vertexes that reinforce the volumetric readings of his volumes. This together with the absence of external articulation, apart from the alternating horizontal and oblique courses of the concrete bricks, make the massive appearance of his houses the foreground of the viewer's experience.

Size and scale articulation are also some of the means by which massiveness of Botta' s houses is achieved and contrasted to the delicacy of the Corbusian villas. In Botta the size of the volumetric form as a whole is accentuated to prevail over the individual elements. On the other hand, the dissolution of the volume into planes, posts, slots, canopies and other elements by Le Corbusier scale down the solid forms into smaller constituents. Thus, Botta favours the large scale volume and limits articulation to the use of as little elements as possible. Le Corbusier favours the small scale elaboration resulting in a variety of elements.

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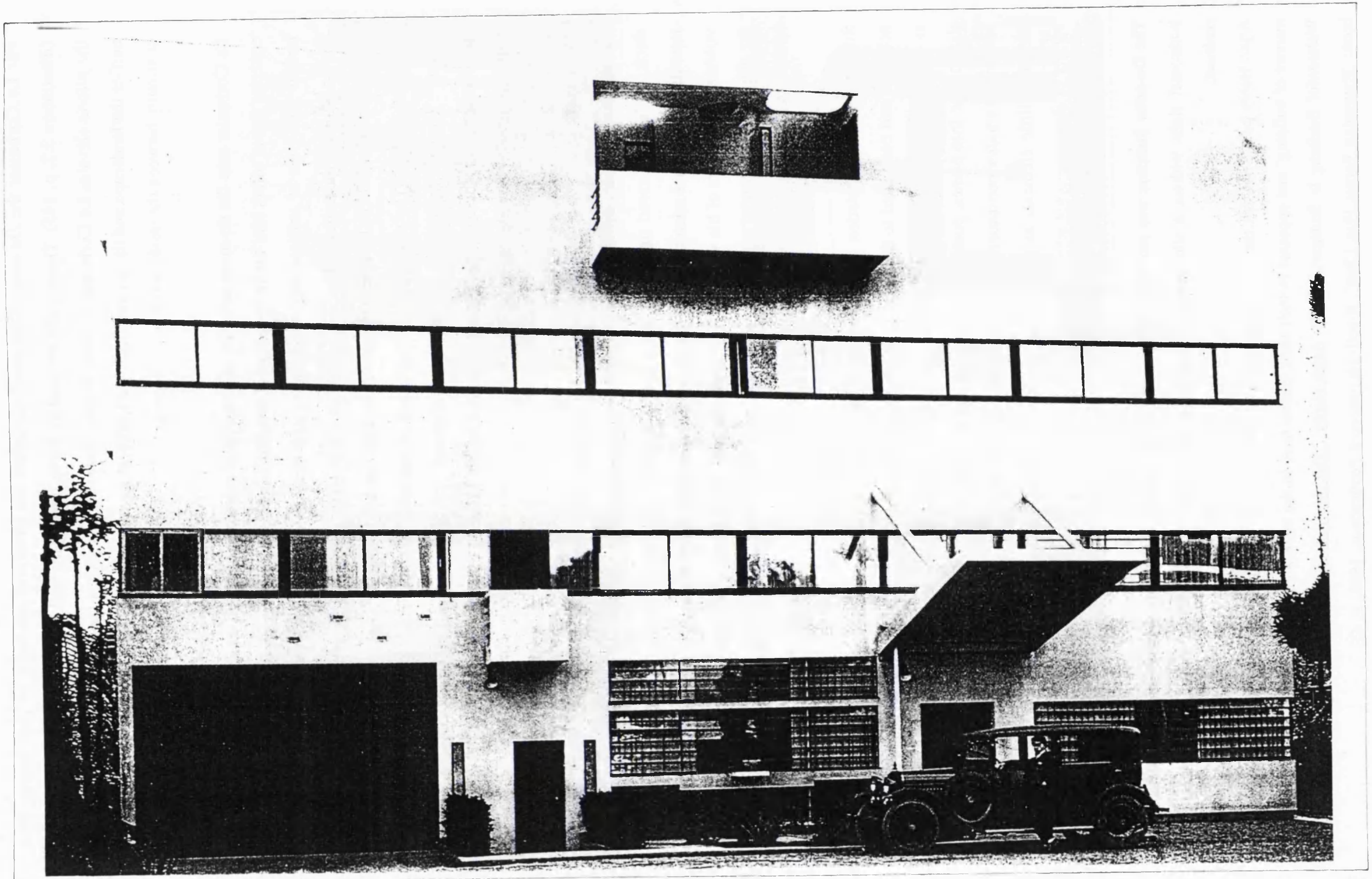
4 The Do-mino Structure was envisaged by Le Corbusier as a concrete skeleton of linear support elements and horizontal slabs without a standardised living programme. Within this skeleton various houses could be realised.

5 Arjan Hebly points out that the 'five points' were introduced as 'architectural facts indicating an entirely new manner of building' and appeared in their most known form in the book published to mark the opening of the Weissenfof Siedlung in Stuttgart, (1927), Arjan Hebly, 'The five Points and Form', essay published in the book: 'Raumplan Versus Plan Libre', Rizolli International Publications, 1988, p. 47.



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- **Similarities and differences in the geometrical articulation of the volumes**

Other differences between the two architects refer to the geometrical organisation of their volumes. Botta adopts the classical approach using bilateral symmetry. However, he replaces the classical idea of the windows as holes on the wall surface by a glazed shaft that cuts vertically the volume into two equal solid parts, (illustrations, 3.7-3.10, p. 147). Le Corbusier questions bilateral symmetry the same way he questions other features of the classical three dimensional articulation, i.e. the solid wall structural system, the windows and the pitched roof. As opposed to Botta who totally accepts the subordination of all the elements to the geometrical axis of symmetry, Le Corbusier neither fully adopts the issue nor fully denies it.

At the front elevation of Villa Stein, for example, the top floor terrace is centrally placed, (illustration, 3.11, p. 148). The axis of symmetry introduced by this terrace is reinforced by the symmetrical placement of a balcony on the left and of a canopy above the main entrance on the right. These two elements are symmetrical in terms of position and asymmetrical in terms of physical appearance. This example seems to show that Le Corbusier seeks order in the subtle application of geometrical rules rather than in an absolute realisation through identical figurative elements.

Both architects use simple geometrical shapes. Their blocks are the simplest manifestations of geometric control over the general form of the houses. Regularity and simplicity reveal an intention to enable the viewer to grasp the building's overall shape. However, Botta seems to strive for simplicity expressed by overall symmetry from the largest to the smallest elements. Le Corbusier challenges this simplicity by deviations from overall symmetry as well as by a complex local scale articulation achieved by the dissolution of the blocks into distinct elements.

Thus, it seems that an initial hypothesis can be formed suggesting that structural simplicity in Botta generates a unity of perception. On the other hand complexity in Le Corbusier creates a system that is not directly perceived at a single glance and from a single point of view. Le Corbusier himself described how lessons from Arab architecture showed him the merits of knowing a building from a multiplicity of view points linked together through movement and exploration..

'Arab Architecture has a precious lesson for us. You appreciate it on foot, walking. Only on foot, in movement, you can see the developing articulation of the Architecture. It's the opposite principle to that of Baroque Architecture which is conceived on paper, from a theoretical view point. I prefer the teaching of Arab Architecture'[6].

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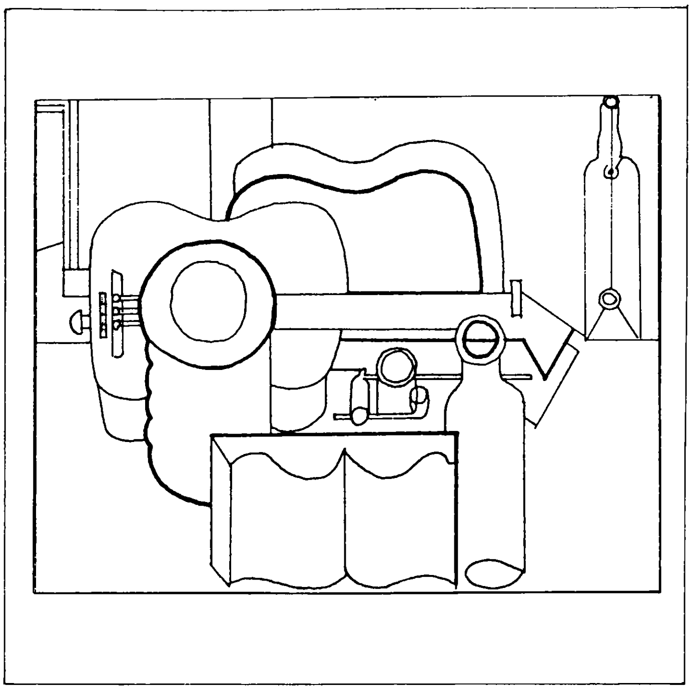
6 Le Corbusier, 'Oeuvre Comlete', II, p. 24.



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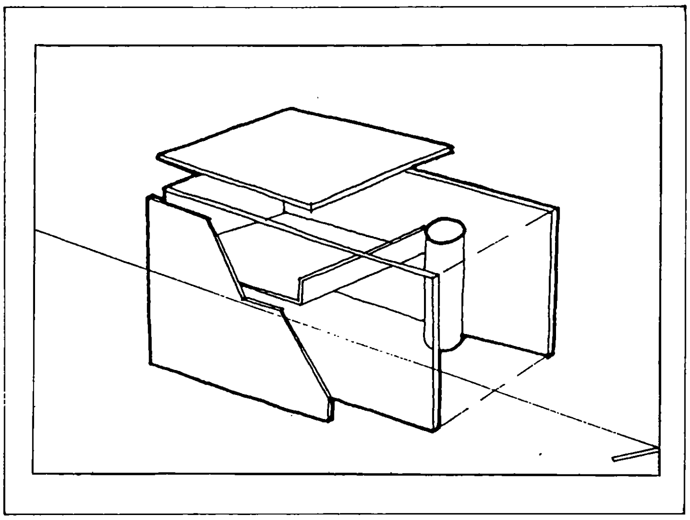

⑬

The notion of 'promenade architecturalle' has been often seen as related to the cubist idea of movement. The organisation of pictorial space in painting completes with Cubism the dislocation of the traditional concept of space originally started by Cezane. Cubism achieved a simultaneous representation of an object from several angles so that the flat picture provides clues that one is aware of only by movement and touch implying, thus, a 'virtual mobility'[7] of the viewer.

Maurice Besset relates the general theoretical attitude of cubism towards conception of three dimensional space on a flat surface to the attitude of Le Corbusier towards real three dimensional architectural space. Thus, the virtual mobility implied by a cubist painting is translated by Le Corbusier into real mobility around and through a building. As Maurice Besset writes:

'Transposed to the plane of practicable space of architecture, this new mobility made it possible to break with the classical system of static, purely visual, arrangements composed in terms of axes and symmetries and to endeavour to integrate within architecture the sum total of the complex experience of movement'[8].

Various authors have pointed to other aspects of Cubism that also have an impact on Le Corbusier. In cubist paintings familiar object types are destroyed on the plane and they are replaced by fragments drawn from different angles each one related to a different view point. Geoffrey Baker discusses the relationship between the buildings of Le Corbusier and Cubism drawing attention to the object types which he used in his own paintings and their relation to the cylinders and various planes he uses in Maison Citrohan, (illustrations 3.12, 3.13).

'In the Citrohan House the solids (cellular units), cylinder (spiral stair) and various planes are deployed in a state of dynamic equilibrium resembling in the third dimension the two dimensional technique used in the paintings'[9].

Other characteristics of Cubism are the fundamental techniques painters always used to imply and represent spatial depth on a two dimensional surface like transparency and overlap. Gombrich suggests that in cubist paintings the outline of elements is seen travelling behind other elements. He proposes that this expresses real experience where the continued existence of objects half hidden by other objects is deciphered[10].

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7 Maurice Besset, 'Le Corbusier , To live with Light', Editions d'Art Abert Skira, 1987, p.

8 Maurice Besset, Ibid., p. 40.

9 Geoffrey Baker, 'Le Corbusier - An Analysis of form', Van Nostrand Reinold, 1989, p. 97.

10 E. H. Gombrich, 'Art and Illusion - A Study in the Psychology of Pictorial Representation', Phaidon Press Limited, 1977, p. 239.

Rowe has associated the arrangement of the frontal vertical planes of villa Stein with transparency and overlap suggesting that the building creates a multiple awareness of planes 'which interpenetrate without optical destruction of each other'[11]

- **Hypothesis and arguments - a brief summary**

Regardless of the influence of Cubism on Le Corbusier the above considerations seem to lead to a first hypothesis. Le Corbusier displaces unity of perception by a multicoded, multifaceted experience developed through movement and extended exploration. On the other hand, Botta seems to prefer the static system of classical ordering with its axial symmetries perceived from a single point. Analysis is hoped to test this hypothesis providing also with something the above authors have not offered: *a clear account of how Botta and Le Corbusier achieve these effects through the manipulation of their formal systems.*

An examination of the volumetric articulation of these houses carried out in this chapter seems to reconfirm this hypothesis. It will be argued that in Botta's houses symmetry on the back to front axis organises the volume as a whole uniting all three layers of properties, i.e. physical, shape and grid properties. In Le Corbusier there is more than a single rule governing the volume as well as each layer of properties.

Botta's houses are grasped as simple volumes that are symmetrically sculptured on the axis of symmetry in both two and three dimensions. Le Corbusier's houses are read as more complex systems accommodating more than a single reading. Thus, they are seen as simple volumes that are excavated to define voids and solids as well as a system of volumes that are decomposed into volumetric and planar components. They are also understood as asymmetrical arrangements within the symmetrical format of a geometrical grid.

A simple volume that is symmetrically organised on a single axis generates not only a single reading but also a reading that is the same from different positions. Therefore, an observer looking at Botta's buildings can grasp the organisation of the volume from limited points of view. A more complex volume organised by subtle and hidden symmetries of grid lines creates multiple readings that are different from different positions. Thus, Le Corbusier's buildings seem to encourage the viewer to move around in order to build a complete picture of the buildings

It will be also suggested that the different ways in which the buildings of the two architects are understood is determined by the different ways in which they approach transformation. In Botta transformation of the volume from its abstract to its specific state is guided by the physical and

11 C. Rowe, 'Transparency : Literal and Phenomenal', in the book: 'The Mathematics of the Ideal Villa and other Essays', The MIT Press, Cambridge, Massachusetts and London, 1982, p. 168.

geometrical characteristics of the former. In other words, all stages preserve the same characteristics of the largest volumetric component describing the building's overall shape. In contrast, transformation in Le Corbusier follows a dual course of development. This is based on an alternating preservation and abandonment of the properties of the first stage. Within this context, the hypothesis formulated in the previous chapters is reaffirmed: *formal properties and the ways they are intelligible are based on the notion of transformation.*

The two different approaches to transformation reveal two different approaches to composition. Botta directing his design process according to the rules of the simplest and largest volume shows that he has a pre-existing knowledge of the final product. Le Corbusier challenging the hierarchical application of rules from the largest to the smallest component demonstrates that he has no pre-conceived idea of the final stage. Botta controls his design choices to satisfy an already known result. Le Corbusier opens up his design choices to release potential unknown results. These observations reconfirm the second part of the hypothesis concerning the relationship between formal description, intelligibility and composition: *The description and understanding a formal system carries with it a description and understanding of its process of construction, i.e. a description and understanding of composition.*

## DESCRIBING THE METHODOLOGY

The analysis of elementary configurations carried out in chapter two reached particular suggestions regarding a methodology for analysing the formal properties of configurations. These are the following:

- Analysis can study volumetric configurations as transformations. A transformation is a structural concept consisting of a class of elements combined together by some operation. The properties that remain invariant define the 'group of the transformation' i.e. the formal properties of the configuration.
- Analysis can distinguish between three layers of properties: ***physical***, ***shape*** and ***grid properties***.

- **Describing formal properties as groups of transformations**

Analysis studies formal properties as transformations progressing in stages form the abstract-generic to the **specific state** of the buildings and from the global to the local scale articulation. The abstract-generic state is defined as the largest volumetric shape that describes a building. The specific state is the actual building itself in its final form of volumetric appearance. The stages in between result from certain operations that gradually transform the volume from the abstract to the specific state.

- **Physical, shape and grid properties**

Physical properties define the contour configuration of a shape. They specify the physical demarcation of its surfaces, its edges and vertexes and make it appear as a physically identifiable entity[12].

Shape properties refer to geometrical relations among the points defining the contour and the area of a shape. Grid properties refer to the geometrical relations among the lines generated by the extensions of these contours. Unlike the physical properties, shape and grid properties are not directly visible. This is because they refer to the abstract structure of configuration and not to its visual representation as a concrete, physical concept.

As opposed to the physical properties that are directly visible and *explicitly present*, the shape and grid properties are inferred through an *implicit presence.* In figure 3.2, (p. 203) the unifying contour of the two spaces is explicitly stated by the continuous uninterrupted line that defines both shapes. In figure 3.1, (p 203), the geometrical axis passing from the centres of the two rooms is not manifested on a continuous concrete element. However, it is identifiable through the simultaneous coverage of the geometrical centres by a single line.

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12 Physical properties about relations that are directly visible because they organise concrete representations of abstract rules. For example, a line is a visual product of an abstract relationship between two points. Similarly, a plane is a visual representation of a relationship among three points.

*It should be noted that although physical, shape and grid properties are geometrical properties, analysis uses the term 'geometrical properties' referring to the shape and grid properties. This is to distinguish the observable nature of the former from the abstract nature of the latter.*

Studying physical properties as transformations analysis looks at those characteristics that remain invariant in the transformation of the physical definition of volumes from one stage to the other. The more the defining sides, the edges and the vertexes of the initial volume retain their physical definition the more the physical properties of this volume are retained. The less these elements maintain physical definition the less the physical properties of the initial solid are preserved. These properties are examined through a table of figures that represent in axonometric drawings the transformation of the volumetric appearance of the houses from the generic to the specific state, (TBH1 3.1, fig. 1-5, p. 157).

Looking at shape and grid properties as transformations analysis examines the symmetries that stay invariant when a configuration is seen as an arrangement of shapes and as an arrangement of grid lines generated by the extensions of the elements defining these shapes. Shape and grid properties are studied through a table of figures that show the transformation of the shapes and grids from one stage to the other, (TBH1 3.2, TBH1 3.3, fig. 1-25, p. 158). They are represented and studied in two dimensions by a series of horizontal sections through the volumes. Each of these sections corresponds to a floor level.

These properties are studied in two dimensions for the following reasons:

- Analytic simplicity, i.e. to avoid the complexities arising from a description of properties in three dimensions requiring the identification of a large number of symmetries.
- Methodical and thorough examination of complex volumes that can be fully described only through a series of sections. This is particularly useful in Le Corbusier's buildings where the configuration of the volume changes along the vertical direction, (TLH1 3.1, fig. 2, p. 177, TLH1 3.2, fig. 2, 8, 14, 20, 178). Thus, the simpler the volume is the more the horizontal sections have the same contour. In contrast, the more irregular the volume is the more the horizontal sections have different contours.

A superimposition of all sections enables a simultaneous examination of their shape and grid properties, (TLH1 3.2, fig. 30, p. 178). It also allows an examination of the ways these properties are organised at the three dimensional level. The more these sections have the same properties the more these properties govern the volume as a whole. The less they have the same properties the less these properties organise the three dimensional system as a whole.

Physical, shape and grid properties are examined separately as well as in relation to each other. The purpose is to see whether there is a co-ordination or a lack of co-ordination amongst them. The former is based on a preservation of the same characteristics by each layer of properties. The latter is based on a preservation of different characteristics. According to the observations put forward in the previous chapter the more the three layers of properties display the same characteristics the more intelligibility of a system is based on a single interpretation. On the other hand, the more they display different properties the more they generate multiple interpretations.

- **Operations**

Three operations are identified as transforming the volumetric appearance of the houses. These are: ***subtraction***, ***addition*** and ***planar extension***. Subtraction occurs when a volumetric component is subtracted from a volume affecting its physical definition. It creates a void that opens to the outside maintaining physical definition of two to three defining sides, (TBH1 3.1, fig. 2. p. 157).

Addition occurs when a volumetric element is attached to a volume. It alters either a solid by being attached to one of its sides, (TBH1 3.1, fig. 2, p. 157), or the voids created by subtraction by being inserted inside them, (TBH1 3.1, fig. 4, p. 157), or both a solid and a void by being attached to both, (TBH1 3.1, fig. 5, p. 157).

Planar extension occurs when a horizontal or a vertical surface of a volumetric element that is affected by subtraction is extended to redefine its missing sides, edges and vertexes, (TBH1 3.1, fig. 3, p. 157).

Colour is used to distinguish between these operations. Thus, blue colour indicates subtraction, while red stands for addition and planar extension, (TBH1 3.1, fig. 1-5, p. 157).

- **The structure of this chapter**

Before proceeding to the analytic description of houses some further explanations regarding the ways analysis is carried out and the ways this chapter is structured are needed.

Analysis carried out for each house observed fundamental similarities amongst the houses designed by each architect. A separate examination of each house may therefore generate extensive descriptions of similar bodies of data. This is avoided by presenting analytically only a single house of each architect. These are: Botta's house at Viganello and Le Corbusier's Villa Stein. These examples are chosen as the most representative cases of the ways the two architects articulate the formal organisation of their buildings.

The rest of the houses are presented in the context of a comparative examination of all houses following the analytical presentation of those mentioned above. It is believed that within this format it is possible to describe the fundamental characteristics of each house both as an individual case and as a part of a group of houses. However, should the reader wish to examine every house separately he can refer to the appendix which presents each house analytically in separation from the others.

This chapter is divided into three main parts:

- The first part examines Botta's houses. This is based on an analysis of Botta's house at Viganello followed by a comparative examination of all of his houses.
- The second part looks at Le Corbusier's houses. Similarly to the first part, it distinguishes between an analysis of Villa Stein and a comparative examination of all houses.
- Finally, the third part focuses on Botta's houses in comparison to those of Le Corbusier.

The examination of each of the houses is divided into three parts:

- The first part offers a general description of surface characteristics that can be identified from a first point of view.
- The second part progresses linearly from the generic to the specific state providing a separate description of the properties of each stage.
- The third part offers a comparative description of stages. This looks at those properties that are preserved from the first to the last stage and from each stage to the next.

Within this analytical framework and this structure of presenting the data, analysis proceeds to the examination of the houses.

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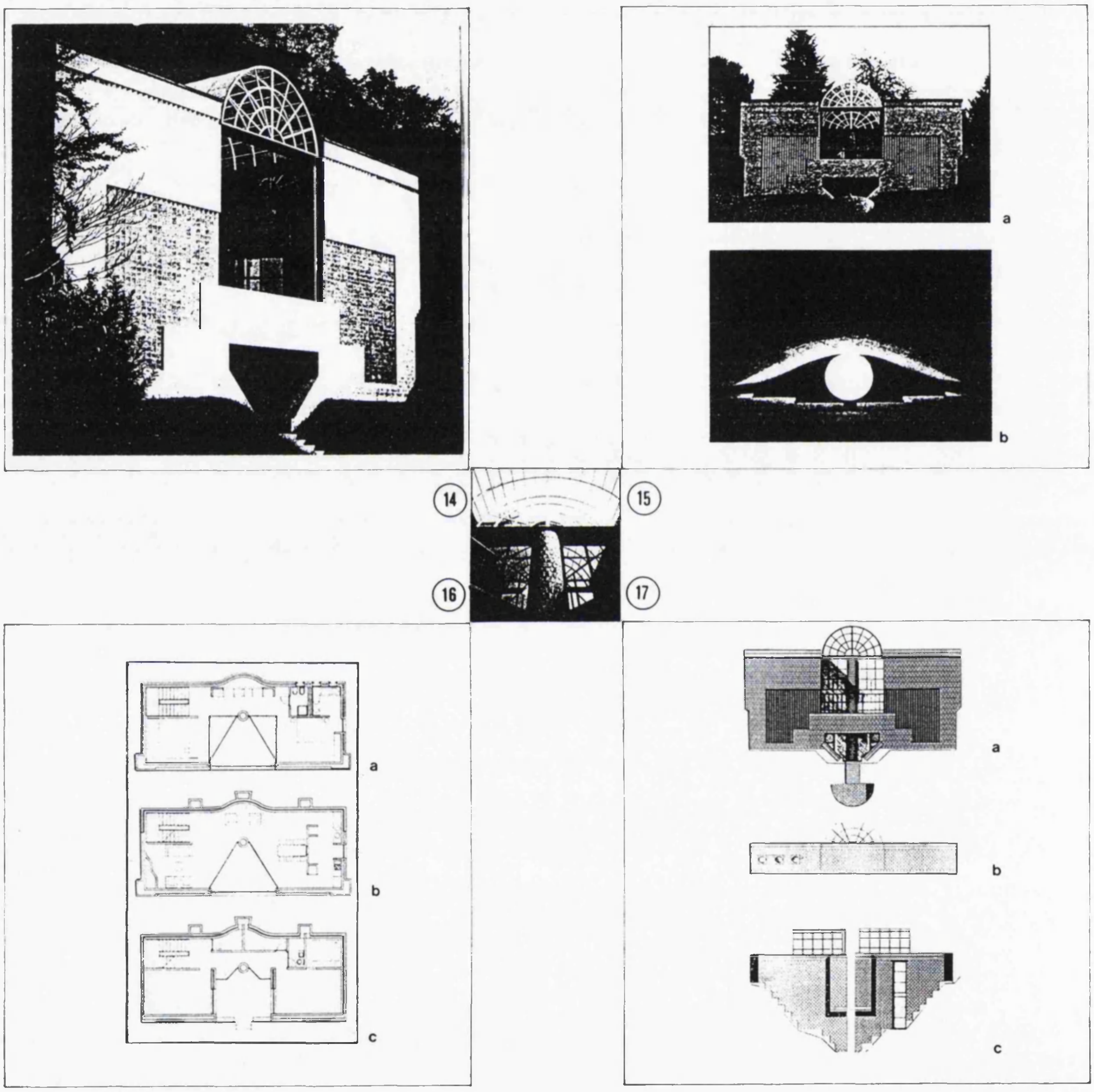

- ## A N A L Y S I S

- ## M A R I O B O T T A - H O U S E A T V I G A N E L L O - ( B H 1)

- ### GENERAL DESCRIPTION, (illustrations 3.14-3.17)

Situated at the suburbs of the town of Viganello this house sits on a slope that overlooks the town, (illustration 3.14). The approach route gives oblique views of the front elevation contrasting its symmetrical arrangement and its frontality. It is only when one reaches a circular piazza lying on the central axis that has a frontal view of the house, (illustration 3.15a).

At the back one third of the volume sinks into the sloping ground. At the front it is exposed towards the views in full height. Plantation conceals its three sides and makes the front elevation its only public face, (illustration 3.17a). The right elevation is centrally pierced by a narrow vertical slot. The left elevation is completely solid, (illustration 3.17c). Finally, the back elevation displays three small circular windows on the left side, (illustration 3.17b). At the centre it curves outwards in full height complementing the vertical void and intensifying the axis of symmetry.

From the back and the sides the house looks defensive. It is from the front that it absorbs inspection and invites the visitor to speculate about its interior space. A vertical shaft slices the volume into two halves flanking a central void. A cylindrical column placed in the middle of the front facing surface of the shaft terminates at a glazed vault that crowns the building and bridges the gap between the two solids. A recessed space at the ground floor articulates the entry in the Palladian manner of a *'portico'*. At the first floor there is a terrace, while at the second floor there are two balconies overlooking the terrace above.

The house is organised in three levels converging on the central cavity of the shaft. The ground floor houses the entry and the service areas, (illustration 3.16c). The first floor contains the living room and dining room surrounding the terrace, (illustration 3.16 b). Finally, the top floor accommodates the bedrooms that are located at the left and right side of the front void and the bathrooms situated at the back of the building, (illustration 3.16 a).

Table **BH1 3.1**

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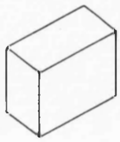
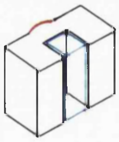
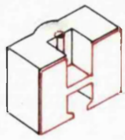
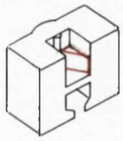
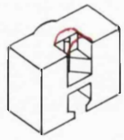
|  1 |  2 |  3 |  4 |  5 | | |

## • DESCRIPTION OF STAGES

The simplest geometric solid that describes this house is a single rectangular volume, (TBH1 3.1 fig. 1)[13]. This volume is defined by the extension of the outer surfaces of the house. Any elements inside or outside these surfaces are not considered in the description[14]. So, at this stage the block is devoid of any openings or of any other forms of articulation.

This block is symmetrical with respect to four axes passing from its geometrical centre. Thus, it can be divided at length, at width and diagonally into two halves that have a mirror relationship to each other with respect to these axes[15], (TBH1 3.2, fig. 1, p. 158).

At stage two a rectilinear rectangular volume is subtracted from the centre of the block. A vertical shaft is created that opens towards the front extending throughout the height of the volume, (TBH1 3.1, fig. 2). The remaining solid is a volumetric U. Further, a curvilinear three dimensional element is added at the back side. This element projects outside the perimeter of the block extending from the base to its top.

The horizontal sections cutting through different height levels of this volume and the roof plan are similar to each other, (TBH1 3.2, fig. 2, 7, 12, 17, p. 158). In this respect, analysis examines the geometrical properties of a single section.

These properties are seen first as properties among a set of shapes. Secondly they are seen as properties among a set of grid lines generated by the extensions of the lines that define these shapes. Starting from the first kind of properties it turns out that the geometrical centres of the block, of the void, and of the curvilinear element are covered by a single axis running from the back to the front of the building, (BF axis), (TBH1 3.2, fig. 2, p. 158).

The geometrical grid consists at length of three equal geometrical bays that are arranged according to the rhythm: A A A. At width two unequal bays are arranged, (TBH1 3.3, fig. 2, p. 158).

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13 Table Botta House 1, 3.1, fig. 1.

14 Elements like the vertical shaft or the glazed vault are not taken into account. It is only the simplest and largest volumetric object the analysis is interested in at this stage.

15 In the previous chapter all reflective and rotational symmetries were specified in the description of properties of a configuration. However, this analysis follows a more conventional approach avoiding rotational symmetries. This is because the transformation of the volume, as this wil be described later, breaks rotational symmetries retaining only the trivial symmetry on 360°.

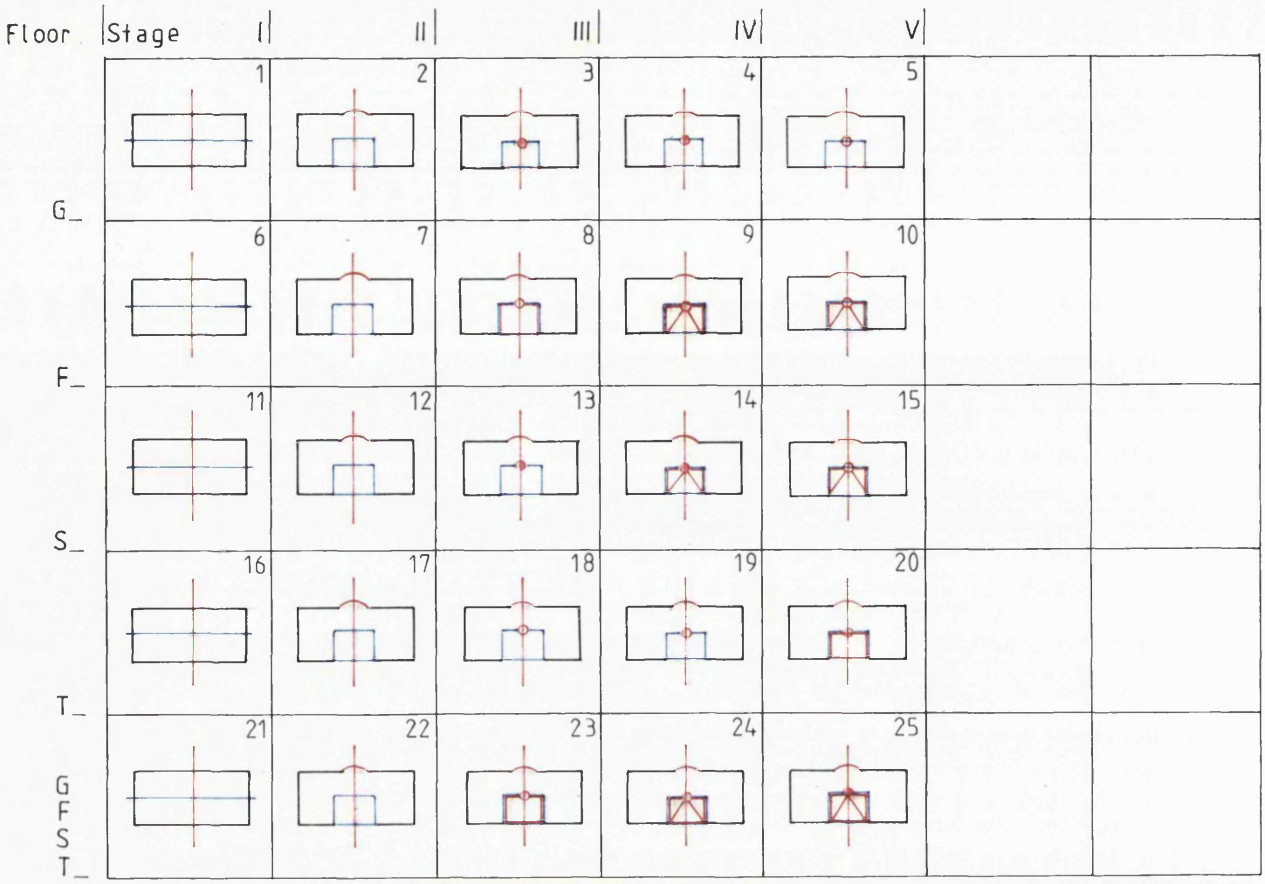


**Table BH1 3.2**
**Shape Geometrical Properties**

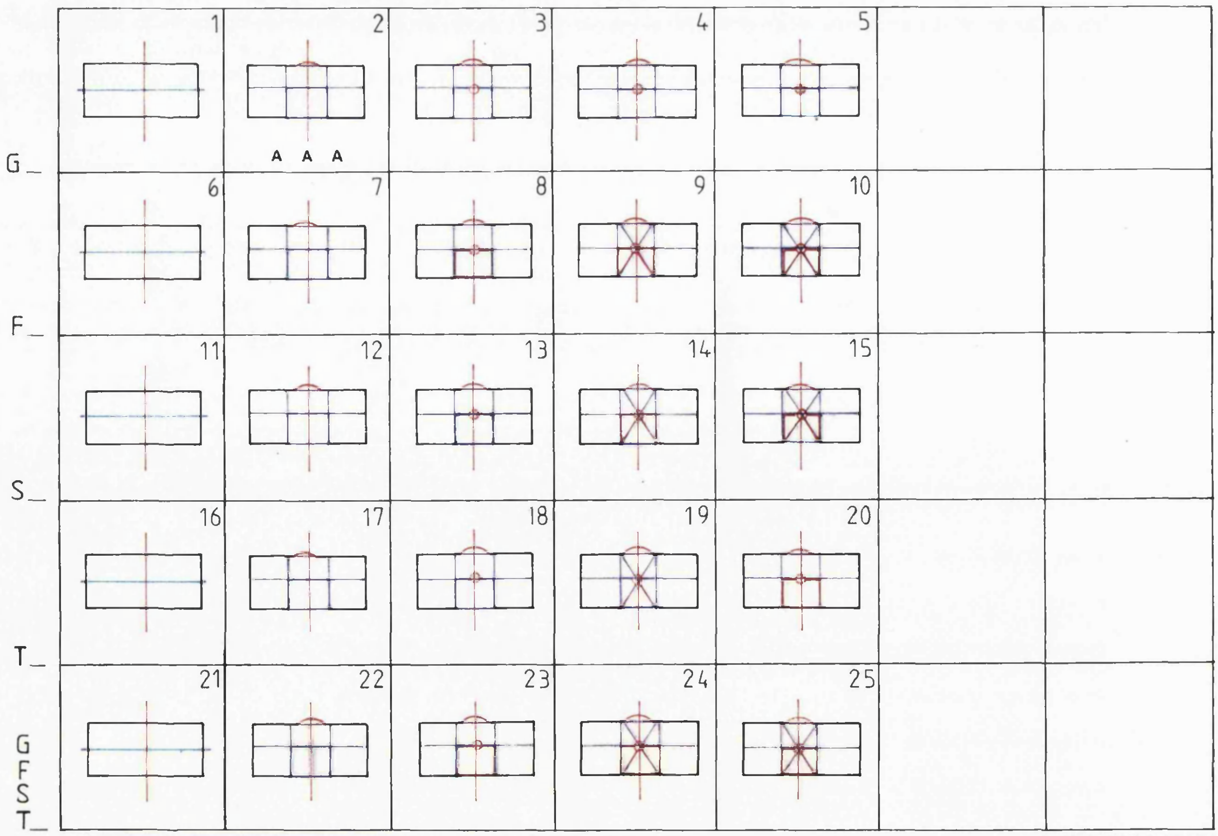


**Table BH1 3.3**
**Grid Geometrical properties**

The grid is characterised at length by the following geometrical properties:
*Reflective symmetry on the BF axis.* According to this property the grid is divided into two symmetrical parts. If it is reflected on the BF axis the lines on the right of the axis will be moved to the lines on the left and vice versa.

*Tripartition.* This property marks a difference between two side geometrical bays and a central bay. The side divisions have the same relationship with the central one.

At width the two geometrical bays do not enter into geometrical relations of this kind. Thus, at this stage the BF axis co-ordinates the block, the void, the curvilinear element and their defining lines, whereas the left to right axis, (LR axis) co-ordinates only the block. Hence, the former appears stronger than the latter.

At stage three a horizontal plane is introduced inside the vertical shaft, (TBH1 3.1, fig. 3, p. 157). A cylindrical column that extends throughout the height of the house is attached at the centre of the front facing surface of this shaft. A horizontal strip is also added in between the two front planes created by the subtraction of the volumetric rectangle at stage two. Further, a symmetrical extension of these planes towards the centre narrows the void at the base.

The geometrical centres of the terrace and of the column lie on the BF axis[16], (TBH1 3.2, fig. 8). The lines defining the terrace coincide with the lines defining the shaft. So, there are no new lines added to the geometrical grid, (TBH1 3.3, fig. 8). The grid properties remain as they are defined at stage two. However, the addition of new elements along the BF axis strengthens its co-ordinating role.

At stage four two equal in size and shape volumetric triangles are attached to the side surfaces of the void. They sit on the first floor terrace transforming its shape from a rectangle to an isosceles triangle, (TBH1 3.1, fig. 4, p. 157).

At the first and second floor sections the geometrical centre of the triangular terrace is located on the BF axis, (TBH1 3.2, fig. 9, 14). Its defining surfaces generate two oblique lines that are symmetrical with respect to this axis, (TBH1 3.3, fig. 9, 14). Thus, the number of elements that are organised by the BF axis is increased further. Besides, from back to front and from left to right the properties of the grid remain as they are defined at stage two.

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16 The horizontal sections cutting through the ground, and the second floor, the roof plan and the superimposition of all sections are similar to each other, (TBH1 3.2, fig. 3, 8, 13, 18, 23). For this reason the analysis concentrates on the examination of the first floor section only.

Finally, at stage five a glazed vault is added at the top of the void, (TBH1 3.1, fig. 5, p. 157). Its geometrical centre is located on the BF axis, (TBH1 3.2, fig. 20, p. 158), while its defining lines coincide with the defining lines of the shaft, (TBH1 3.3, fig. 20, p. 158). Although there are no new lines added to the geometrical grid the number of elements that are co-ordinated by the BF axis is increased further.

- **COMPARISON ACROSS STAGES**

- **Physical properties**

Three kinds of operations transform the volume along the analytic stages. These are: volumetric subtraction, volumetric and planar addition and planar extension. Subtraction at stage two reduces the physical definition of the front and top surfaces as well as of the top and bottom horizontal edges of the block, (TBH1 3.1, fig. 2, p. 157). However, the volume retains physical definition of all the other edges and surfaces as well as of all the eight vertexes of the initial solid.

Physical definition of a geometrical shape relies on physical definition of its defining elements, i.e. its corners, edges and sides if it is two dimensional, and of its vertexes, edges and surfaces if it is three dimensional. As the previous chapter suggested the physical definition of the corners or vertexes determines the degree to which a shape retains its physical identity and recognizability. If a corner or a vertex is taken away then its completion requires reconstruction of this corner or vertex by the extension of more than one surfaces, (fig. 3.6, p. 203). If its corners and vertexes remain physically defined, although its restoration might require the extension of one or more surfaces, it retains a physical connection with its previous condition, (fig. 3.5, p. 203). Thus, at stage two no reconstruction of a vertex is required. The physical identity of the block is preserved.

The planar extension of the front planes and the connecting strip at stage three strengthen the physical definition of the front surface strengthening also the physical demarcation of the block, (TBH1 3.1, fig. 3, p. 157). Finally, the addition of the first floor terrace, of the column, of the triangular volumes and of the skylight at the following stages transform only the vertical void without affecting the physical definition of the block, (TBH1 3.1, fig. 3, 4, 5, p. 157).

Thus, it seems that in every stage the operations transforming the volume preserve the physical demarcation of the initial solid. These operations define secondary volumetric components without modifying the corporeal condition of the largest volumetric element. The initial solid features, thus, throughout the analytic sequences as a physically recognisable object.

- **Geometrical properties**

In each stage the subtracted, the added shapes and their defining lines are symmetrical with respect to a single axis running from the back to the front of the composition, (TBH1 3.2, TBH1 3.3, fig 1-25, p.

158). Thus, in each stage the properties of the shapes coincide with the properties of the geometrical lines that these shapes generate.

This axis coincides with the BF axis passing through the geometrical centre of the block. Therefore, the properties of the first stage coincide with the properties of the other stages. Further, the BF axis is gradually strengthened by a gradual increase of the number of elements it co-ordinates.

In every stage the BF axis organises symmetrical relations among the components and their grid lines in each horizontal section controlling, thus, symmetrical relations at the scale of the building as a whole. The house can be reflected on the BF axis in a way that the side on the left coincides with the side on the right.

Besides, the same tripartite organisation among a central bay and two side ones is maintained throughout the stages. A gradual addition of elements that are constantly described by the same lines that define the shaft, like the first floor terrace and the curved skylight, strengthens the tripartite arrangement and intensifies the central division.

To summarise, in each stage the physical and the geometrical properties of the volume in process are incorporated into the properties of the previous stages. A gradual intensification of these properties is built along the analytic sequences suggesting that there is a systematic tendency to preserve, to maintain and to strengthen the properties of the initial solid.

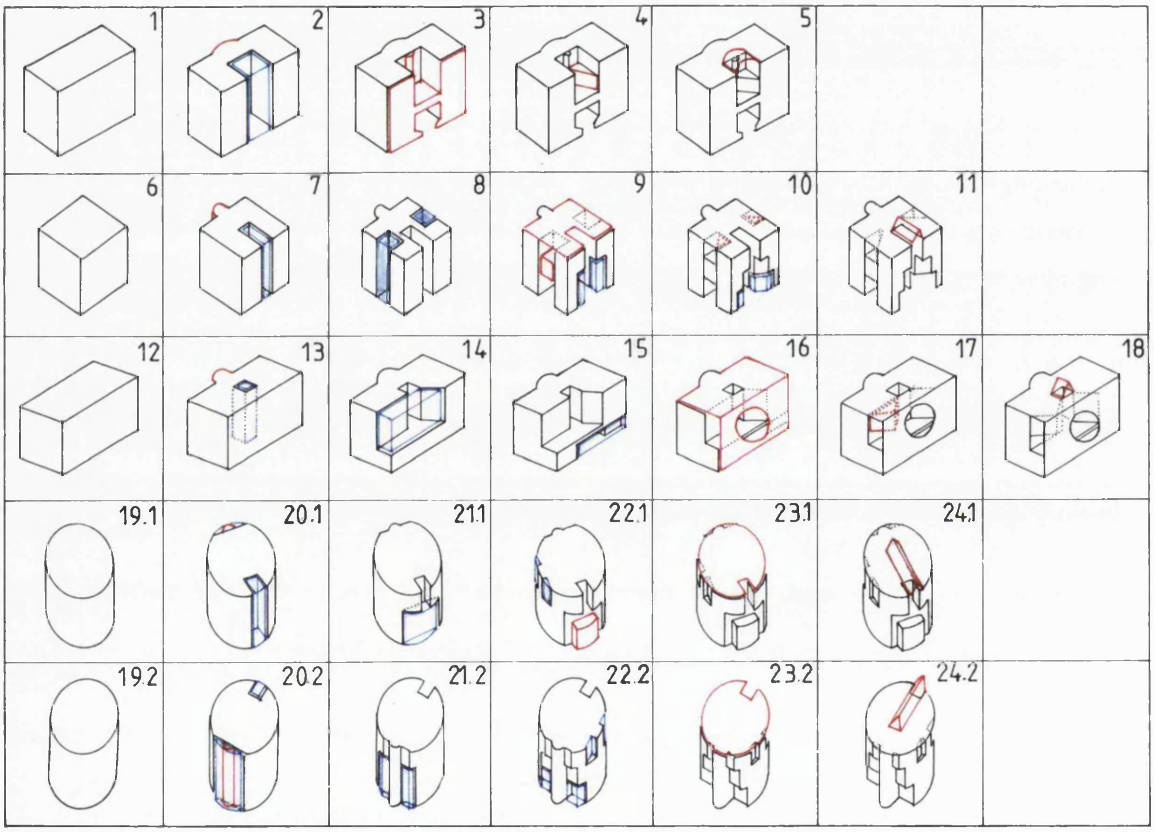

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Table B 3.1

## • COMPARISON ACROSS BOTTA'S HOUSES

In this section the analysis moves to a comparative examination of all houses with a view to identify their similarities and differences. It starts by raising the following questions:

- Is there any consistent pattern of transformation of the volumes from one stage to the other?
- Which are the rules that govern this transformation? In other words, which are the physical and geometrical properties that remain invariant in the transformation?

To answer the first question analysis looks at the patterns of the transformation process, i.e. it looks at operations, the order in which they occur, and their patterns of recurrence. To answer the second question analysis focuses on the relational logic directing the combination of elements, i.e. on the properties that are preserved along the analytic sequences. The aim is to draw some first conclusions that can lead to an understanding of the ways the formal properties of these houses influence the ways they become intelligible.

## • THE PATTERNS OF THE TRANSFORMATION PROCESS

### • Operations and their order of occurrence

Starting with the first question, analysis pointed out that at stage one all houses are described by a prime geometric solid, (TB 3.1 fig. 1, 6, 12, 19.1, 19.2). This solid is covered by two perpendicular axes running from back to front and from left to right of the composition.

Analysis identified that this prime solid is sculptured by certain recurrent operations. These are: volumetric subtraction, volumetric and planar addition and planar extension. Table BH - S, (p. 162), presents the pattern of occurrence of subtraction in relation to the analytic stages. This table shows that subtraction is applied at the five first stages in BH2 and BH4 and at the first four stages in BH3. BH1 is the only case where subtraction is limited at stage two, (TB 3.1, fig. 2).

Table BH - A and BH - E, (p. 162), present the operation of addition and extension in relation to the stages they take place respectively. Looking at these tables it turns out that addition is strongly associated with the second and the final stages in all houses, while extension takes place two stages before the final stage in BH1, BH2 and BH3[17]. Thus, there seems to be a certain order in which operations take place. This shows *there is a consistent pattern of transformation that associates particular stages with particular operations.*

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17 The only exception is BH4 where planar extension takes place one stage before the final one, (TB 3.1, fig 23).

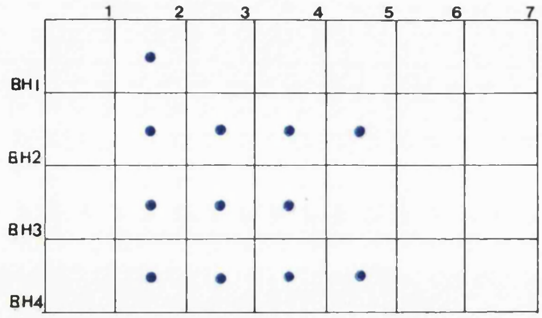


Table BH–S Subtraction

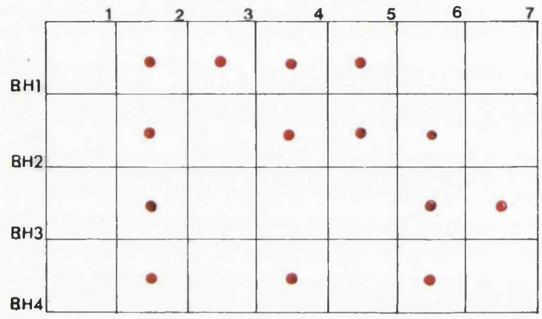


Table BH – A Addition

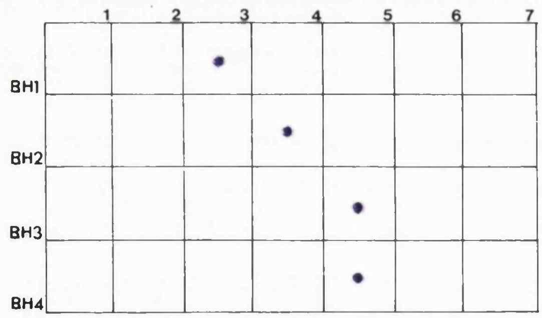


Table BH–E Extension

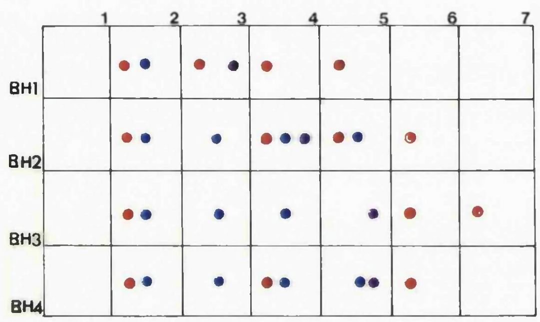


Table BH–SAE

## • THE RELATIONAL LOGIC OF COMBINATIONS

### • Types of shapes - types of combinations

Subtraction at stage two slices the volume from the bottom to the top creating a central void that opens towards the front[18]. The volume is, thus, transformed to a volumetric U. From stage three to stage five subtraction either excavates the left and the right sides of the volumes[19] or it increases the size of the front void[20].

Planar extension stretches either the front or the top surface or both the top and front surfaces of the block in a way that these reach its outer edges[21]. Addition at stage two attaches a curvilinear element at the back side of the volume that covers the height of the building as a whole, (TB 3.1, fig. 2, 7, 13, 20, p. 161). At the following stages addition subdivides the front or the side voids by inserting planar or volumetric components[22]. Finally, at the last stage it attaches a glazed volumetric component to the top of the building, (TB 3.1, fig. 5, 11, 18, 24, p. 161).

To recall, the transformation process starts with a simple geometric solid. Then it proceeds to the transformation of this solid to a volumetric U by the subtraction of a rectilinear rectangle from its centre. It also changes the side opposite the void by the attachment of a curvilinear component. At the following stages it expands the front void and subdivides the side voids. It also extends certain surfaces of the volume to enclose the voids and redefine the block. At the end it crowns the front void by a glazed volumetric element.

---

18 The shaft at BH3 is an exception because it is enclosed inside the volume opening only towards the top, (TB 3.1, fig 13, p. 161). However, at the following stages it opens also towards the front.

19 The only exception is BH1 where only the front side is excavated, (TB 3.1, fig. 2, 3, 4, 5, p. 161).

20 In BH2 the front void is gradually enlarged towards the base, (TB 3.1 fig 8, 9, 10, p. 161). In BH3 the vertical shaft, initially enclosed within the block, opens towards the front and the sides, (TB 3.1, fig 14, 15, p. 161). In BH4 both the front and the back voids are expanded towards the bottom., (TB 3.1, fig 21.1, 21.2, 22.1, 22.2, 23.1, 23.2, p. 161). BH1 is again an exception since the front void is not enlarged.

21 In BH1 and BH3 the front surface extends in front of the void, (TB 3.1, fig 3, 16, p. 161). Besides, in all the houses apart from BH1 the top surface of the volume is extended over the side facing voids, (TB 3.1, fig 10, 16, 23.1, 23.2, p. 161).

22 The enlargement of the front voids is followed by a decrease of their size at a following stage. This is usually achieved by the insertion of volumetric or planar elements that subdivide the open space into smaller compartments. Thus, in BH1 a horizontal surface and two triangular volumes are added inside the void, (TB 3.1 fig 3, 4, p. 161). In BH3 a triangular volume defines one storey and two storey high spaces within the top void, (TB 3.1, fig 17, p. 161). In BH4 a volumetric unit is inserted inside the front void at the base of the building., (TB 3.1, fig 21, p. 161). Finally, in BH2 it is the side voids that are decreased in size by subdivision, (TB 3.1, fig 9, 10, p. 161).

Thus, *there seems to be a consistent pattern of transformation that associates particular stages with particular operations as well as particular shapes with particular combinations.*

## • RULES OF COMBINATIONS

### • Physical properties

It is found that subtraction at stage two in BH1, BH2 and BH3 is ruled by a constraint specifying that the initial volume is always excavated at the centre and towards the outside. The remaining volume retains physical definition of all the vertexes and most of the edges, and surfaces of the block[23], (TB 3.1, fig. 2, 7, 13, 20, p. 161).

The block is described as a *physical* object by the property of each of its surfaces to intersect with two other surfaces forming eight concave vertexes and twelve concave edges that retain four reflective symmetries on the four axes. When these properties change the physical description of the constructed object changes also. The more these properties are preserved the more the new description is close to the initial solid. The volumetric U preserves the property of each surface to intersect with two of the other surfaces to construct eight concave vertexes and ten concave edges that are physically defined. Thus, the transformation is carried out in a way that the new configuration is not different from its origin. It carries with it the physical characteristics of the initial solid.

The operations transforming the block at the following stages preserve also the physical definition of its vertexes. This is achieved by the following devices:

- Excavation hollows out the volume at the centre so that its vertexes remain always solid.
- The front or the top surface of the volume or both surfaces are extended to redefine the block.
- Volumetric addition is also restricted by the same constraint. Elements are added inside or at the top of the voids without affecting the external contour of the volume.

In BH3 excavation decomposes the volumetric rectangle of the first stage, (TB 3.1, fig. 14, 15, p. 161). However, the extension of the roof and of the front plane restores the decomposition of the block emphasising the physical coherence and integrity of the largest volumetric component.

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23 In BH4 there are no vertexes. However, subtraction removes a small part of its top and bottom edges and of its horizontal and vertical surfaces without destroying the round shape of the volume, (TB 3.1, fig. 19.1-24.1, 19.2-24.2, p. 161).

- **PHYSICAL PROPERTIES AND INTELLIGIBILITY**

Thus, all three operations, subtraction, extension and addition are guided by the rules that describe the initial volume as a physical object. A systematic preservation of these rules is established from the first to the last stage and from the scale of the largest to the scale of the smallest constituents. This preservation establishes the priority of the block over the rest of the elements and makes it directly visible and identifiable as a physical concept.

- **Geometrical properties**

- **Bilateral symmetry in two dimensions**

Analysis of each house pointed out that in every horizontal section at stage two the void, the stair drum and their defining lines are covered by the same BF axis, (fig. 2 in TBH1 3.2, TBH1 3.3, p. 171, TBH2 3.2, TBH2 3.3, p. 172, TBH3 3.2, TBH3 3.3, p. 173, TBH4 3.2, TBH4 3.3, p. 174). This axis passes also from the geometrical centre of the block. Thus, a co-ordination is created between the shape and the grid properties as well as between the properties of stage one and the properties of stage two.

- Houses BH1 and BH2

In these house the BF axis controls the distribution of the majority of the shapes and their grid lines at the following stages also. Thus, the co-ordination between the two levels of properties takes place throughout the analytic stages. This results in an increased intensification of the BF axis that is developed systematically from the first to the last stage and from the largest to the smallest components.

- Houses BH3 and BH4

In BH3 the symmetrical organisation of the shapes introduced at the first stages is broken at the third and fourth stage by the introduction of a large scale void at the ground, first and second floor, (TBH3 3.2, fig. 4-7, 10-14, 17-21, 24, 25, p. 173). In BH4 symmetry is also broken by the introduction of two small scale voids at the left side of the volume, (TBH4 3.2, fig. 16, 17, 18, 22, 28, 29, 30, 174). Thus, the hierarchical application of symmetry from the first to the last stage and from the large to the small scale is contradicted by the negation of this formula. Besides, whereas BH3 breaks symmetry by the articulation of large scale elements, BH4 does so by the articulation of the small scale.

However, in BH3 the asymmetrical arrangement of shapes generates grids that are symmetrical with respect to the BF axis, (TBH3 3.3, fig. 10-14, 17-21, 24, 25, p. 173). In BH4 the symmetrical organisation of grid lines on the BF axis is contradicted by the line at the left side of the configuration, (TBH4 3.3, fig 16-18, 22, p. 174). This line does not have an equivalent one at the either side of the axis. However, if this line is excluded and the two geometrical bays at the left are joint into a single one the geometrical grid becomes symmetrical and tripartite. Thus, in these houses a dissociation is created between an asymmetrical shape organisation and a symmetrical grid organisation.

Shape symmetry is not visually represented on a physical element. However, it is directly observable because it organises relations between two equal parts of a physical object. On the other hand, grid symmetry controls relations of elements that are virtually rather than physically present. These elements form a 'hidden' system that requires the virtual extension of surfaces to be deciphered. In this respect, these two houses substitute obvious aspects of symmetrical organisation for less obvious and subtler symmetries.

However, in BH4 the contradiction between an asymmetrical organisation of shapes and a symmetrical organisation of grids is *resolved* by a predominance of shape symmetry operating at the large scale over asymmetry introduced by the small scale articulation[24]. In BH3 this contradiction is *counterbalanced* by the symmetrical organisation of the house as a whole on the level of its external three dimensional appearance, something that analysis will return to in the following section.

- **Reflective symmetry in the third dimension**

At the second stage the components that are added and subtracted from the block extend throughout the height of the volume. This results in horizontal sections that are similar in terms of both shape and grid arrangement, (TBH1-TBH4 3.3, fig 2. p.p. 171-174). At the following stages components are subtracted or added to the volumes at different floor levels. Thus, either one section is differentiated from the other two sections, or all sections are different from each other.

- Houses BH1 and BH2

However, in BH1 and BH2 the geometrical properties of all sections are the same. The BF axis controls the distribution of shapes and their grid lines in the superimposition of all sections organising relations on the scale of the volume as a whole, (TBH1 3.2, TBH1 3.3, fig. 21-25, p. 171, TBH2 3.2, TBH2 3.3 fig 25-30, p. 172). Thus, regardless of differences in figurative arrangement among floor levels, the symmetrical distribution of identical components in each horizontal layer organises the volume as a whole into two halves that are equivalent to each other.

- Houses BH3 and BH4

In BH3 and BH4 the asymmetrical organisation of particular floors disturbs a three dimensional integration of all levels around the BF axis, (TBH3 3.2, TBH3 3.3, fig 31-35, p. 173, TBH4 3.2, TBH4 3.3, fig. 28, 30, p. 174). Nevertheless, in BH3 this integration is achieved by the symmetrical

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24 The analytic sequences move from the simplest and general to the most complex and specific state of the volume and from the largest to the smallest scale. Thus, the properties of the large scale dominate the properties of the small scale.

organisation of the front facade that screens and compensates the asymmetrical placement of the components behind its surface. In BH4 asymmetry is resolved again by the symmetrical organisation of the large scale components prevailing over the deviations created by elements of the small scale.

In BH2, BH3 and BH4 the LR axis plays also an organising role. However, the BF axis appears stronger than the LR axis for the following reasons:

- It becomes activated at an early stage controlling relations of a large scale. The LR axis appears at a later stage organising relations of a smaller scale, (TBH2 3.2, TBH2 3.3, p. 172, TBH3 3.2, TBH3 3.3, p. 173, TBH4 3.2, TBH4 3.3, p. 174).
- It co-ordinates more elements than the LR axis.

- **Tripartition**

The grid of all houses at stage two consists of three or five geometrical bays that enter into tripartite relations with respect to the central bay running from the back to the front of the configuration, (TBH1-TBH4 3.3, fig 2, p.p. 171-174). At the following stages the grids are subdivided accommodating geometrical bays that are also arranged according to tripartition in relation to the same geometrical bay. Analysis shows that the tripartite schema operates in all horizontal sections organising relations in three dimensions. Like symmetry, it is applied hierarchically from the first to the last stages and from the large to the small scale.

Whereas axial co-ordination puts the emphasis on the BF axis, tripartite co-ordination puts the emphasis on the central geometrical bay. Increased number of bays integrated by the central one increase the strength of the tripartite principle and intensify the dominating role of the central bay. The intensification of a rule introduced at the second stage shows that there is a hierarchical order which ensures the priority of this stage over the others.

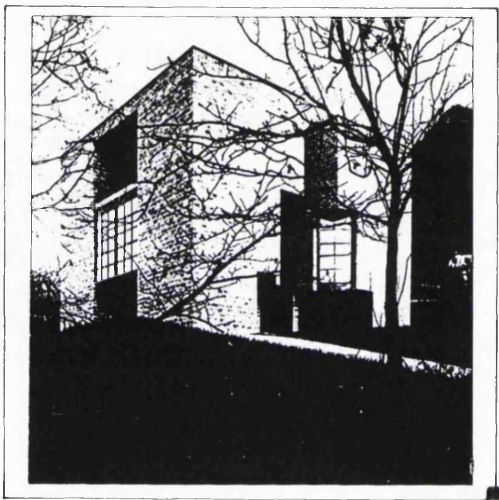
At BH2, BH3 and BH4 the tripartite rule operates along the back to front direction also. Nevertheless, the central bay at length is stronger than the central bay at width co-ordinating a larger number of geometrical bays.

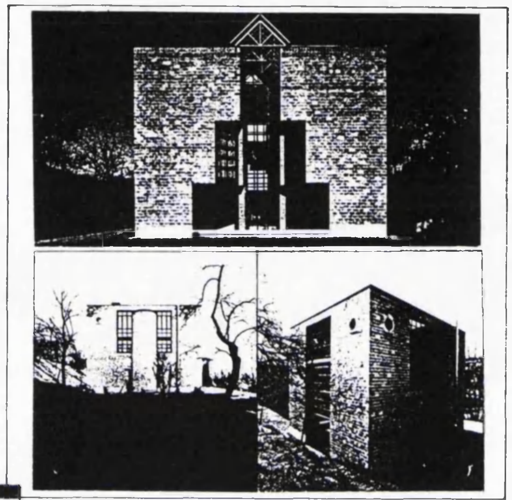
- **GEOMETRICAL PROPERTIES AND INTELLIGIBILITY**

Similarly to the rules of physical articulation the shape and grid rules of the first stages direct the transformation in process constraining the disposition of all elements in both levels of geometrical properties. Thus, both the BF axis and the BF geometrical bay are gradually intensified gathering an increasing number of constituents under their co-ordinating power.

As it was mentioned before, geometrical structures are not explicitly represented on the level of observable appearances as physical structures are. However, in these houses a systematic emphasis on simple geometrical principles results in an increased accentuation of their implicit physical definition. It seems that the more elements are synchronised under a single geometrical property the more this property tends to be raised to the level of the observable structures. Thus, the axis and the central geometrical bay become recognisable as structural concepts reinforcing the geometrical elements they spring from, i.e. the block and the volumetric U.

The hierarchical application of rules existing from the first stage seems to suggest that the aim is to facilitate and ease intelligibility of the houses based on the geometrical structure of the largest and simplest volumetric components. This coupled with the preservation of their physical properties make these components the first geometrical concepts that attract the viewer's attention becoming the dominant features of his perception of the building as a whole.





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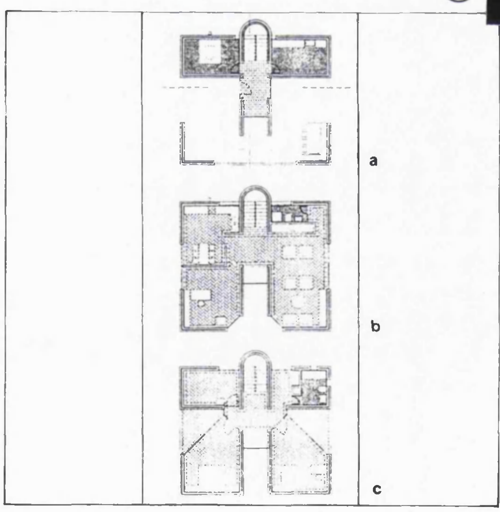
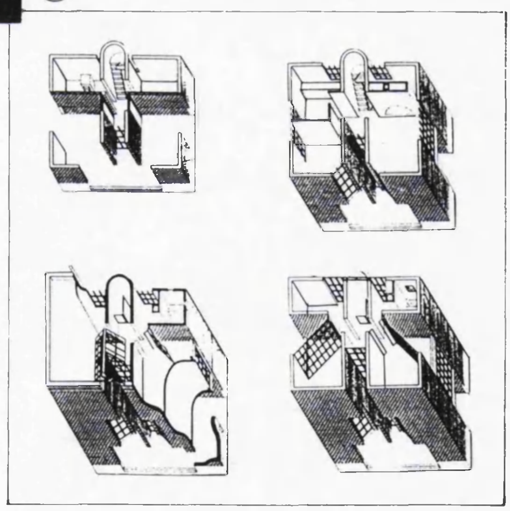
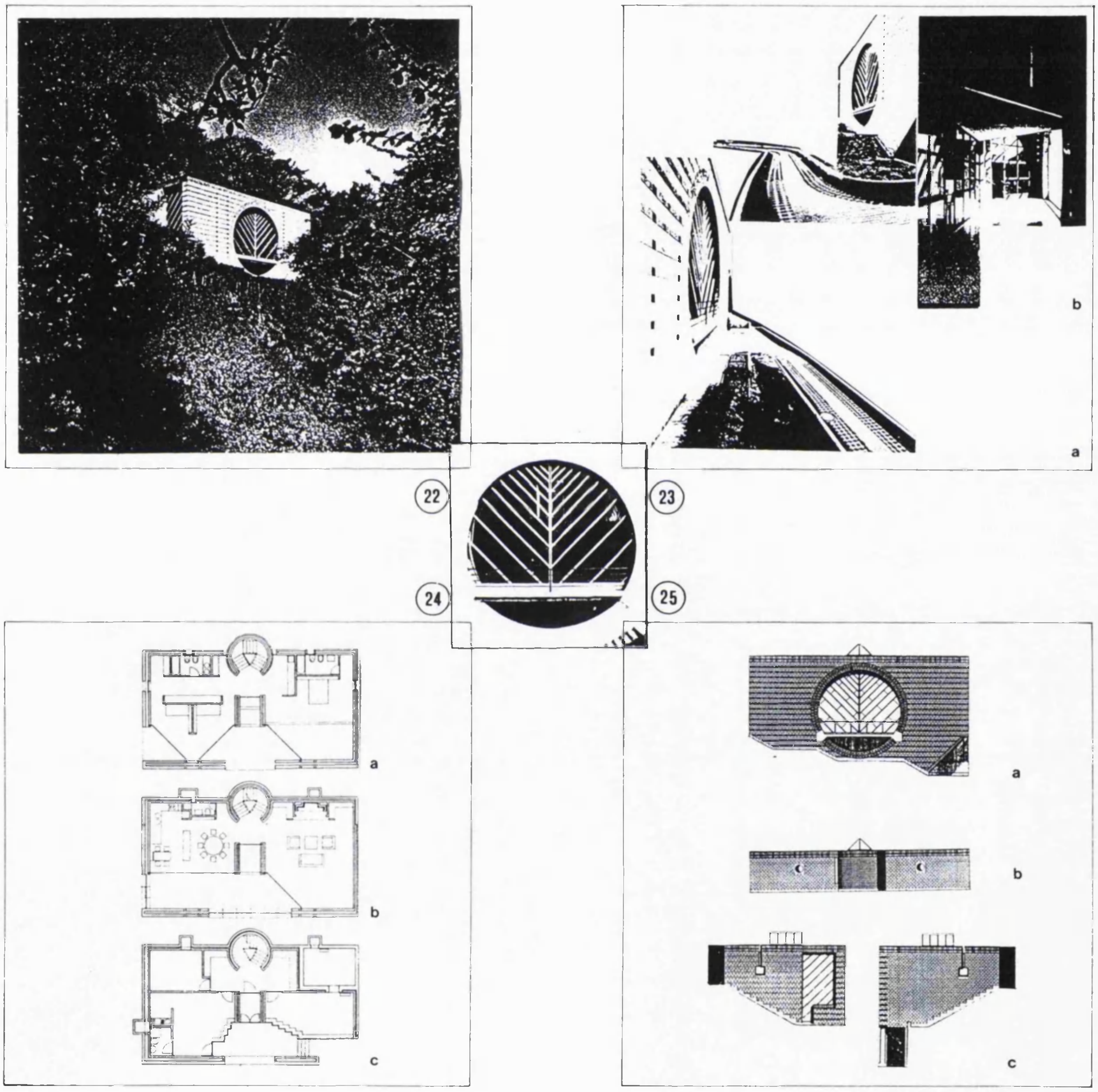
(20) (21)

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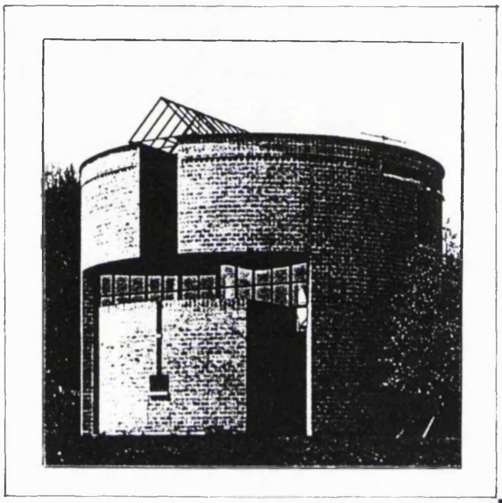

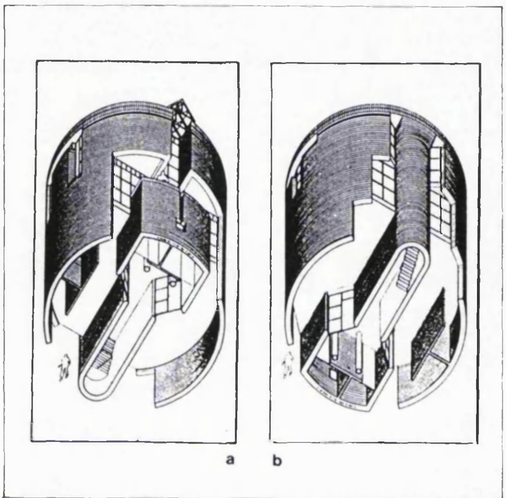


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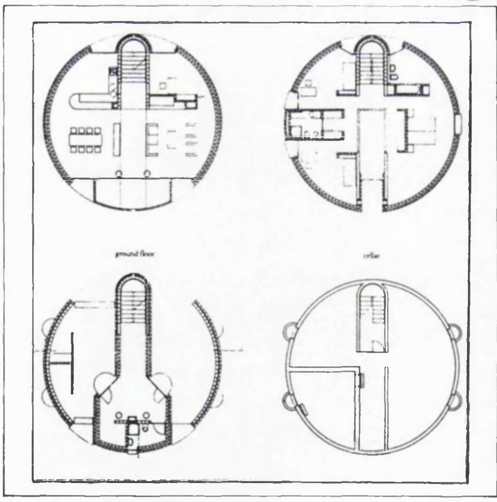
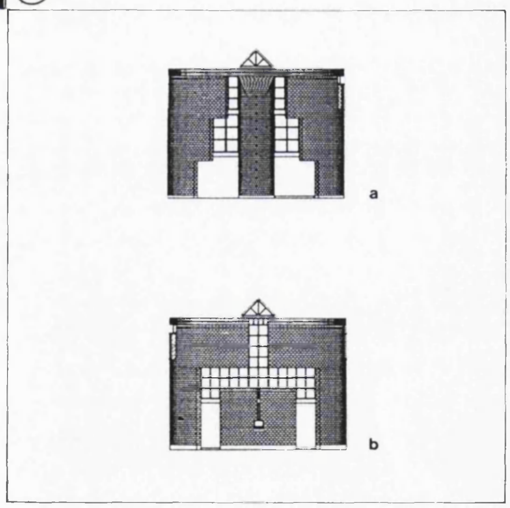




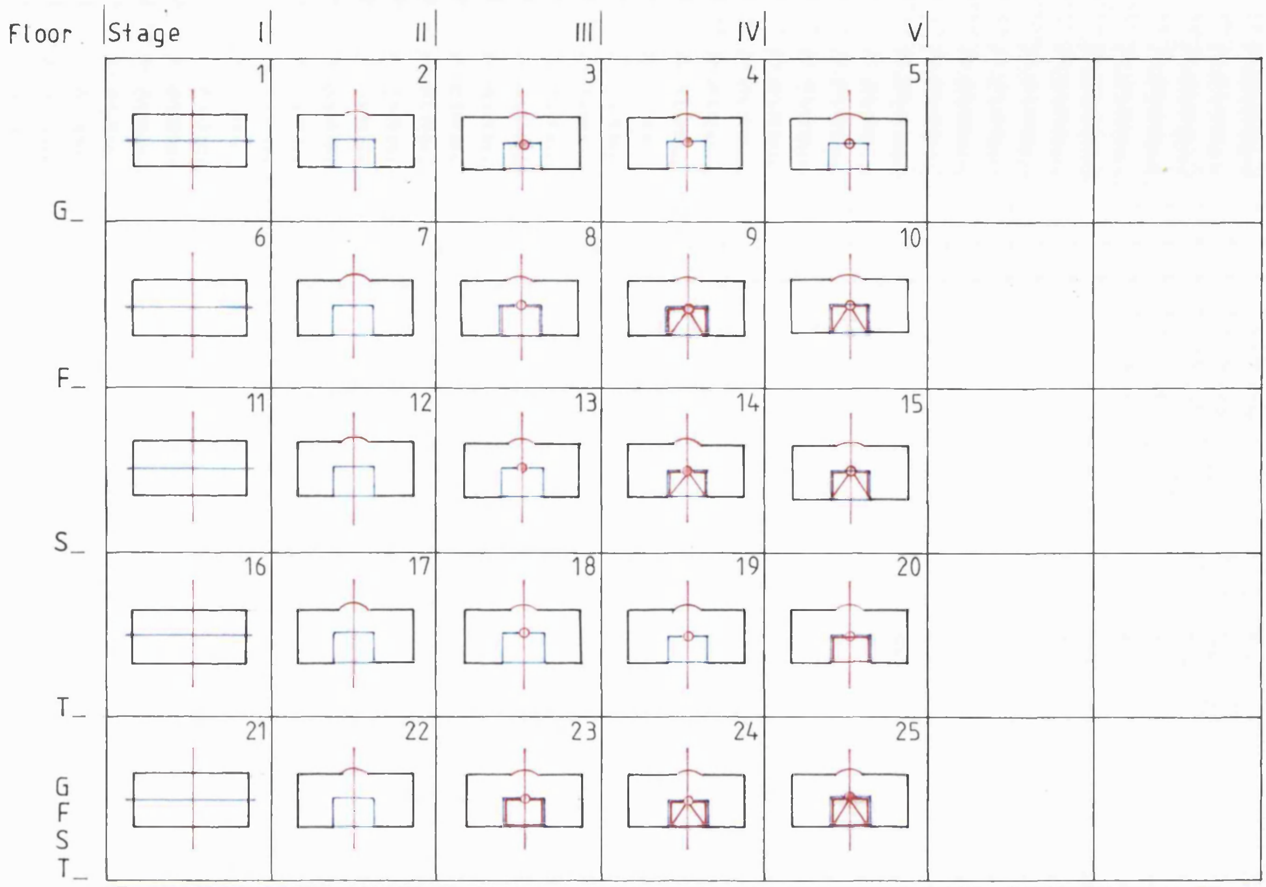



Table BH1 3.2
**Shape Geometrical Properties**

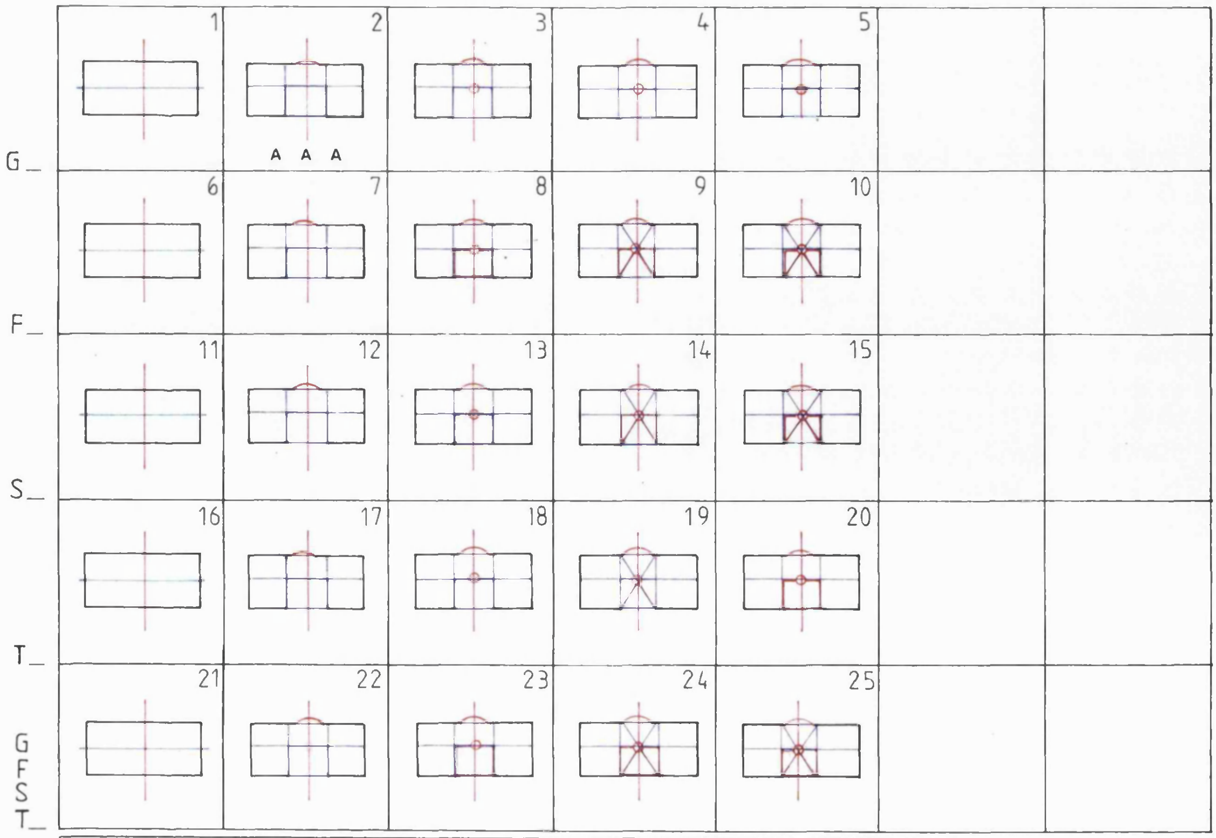



Table BH1 3.3
**Grid Geometrical properties**

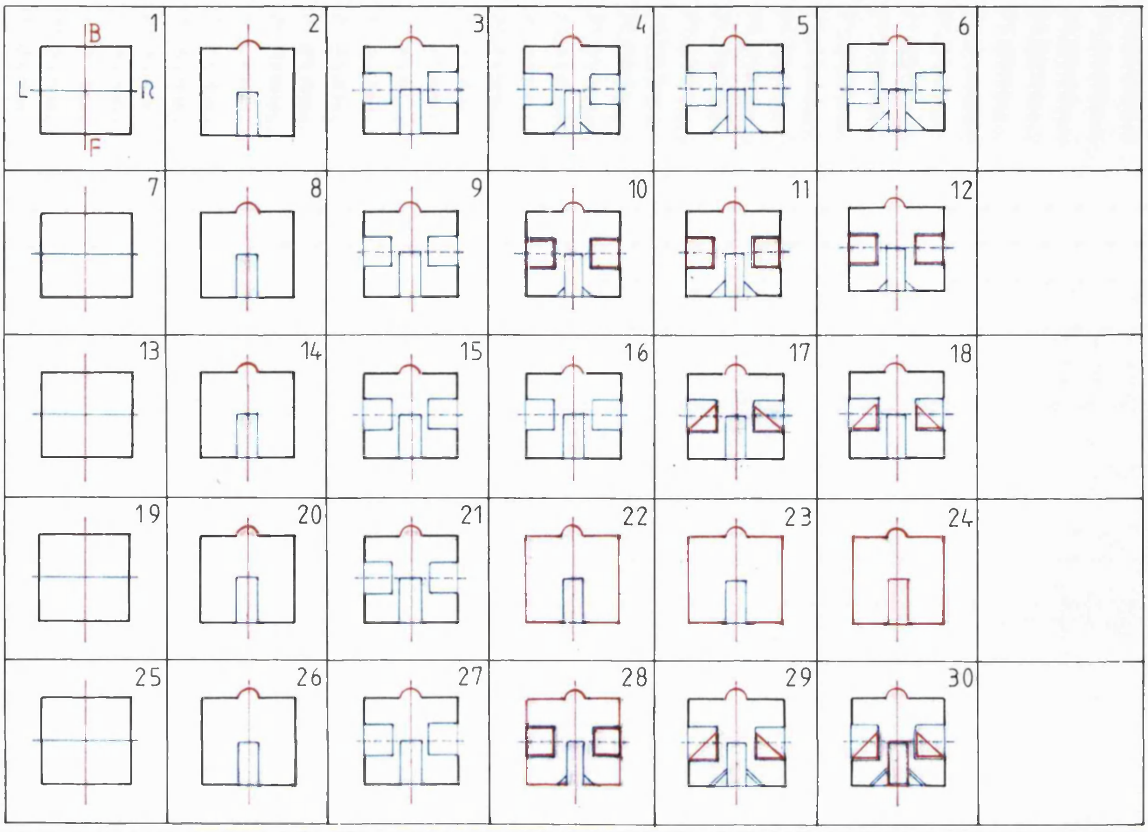



Table **BH2 3.2**
**Shape Geometrical Properties**

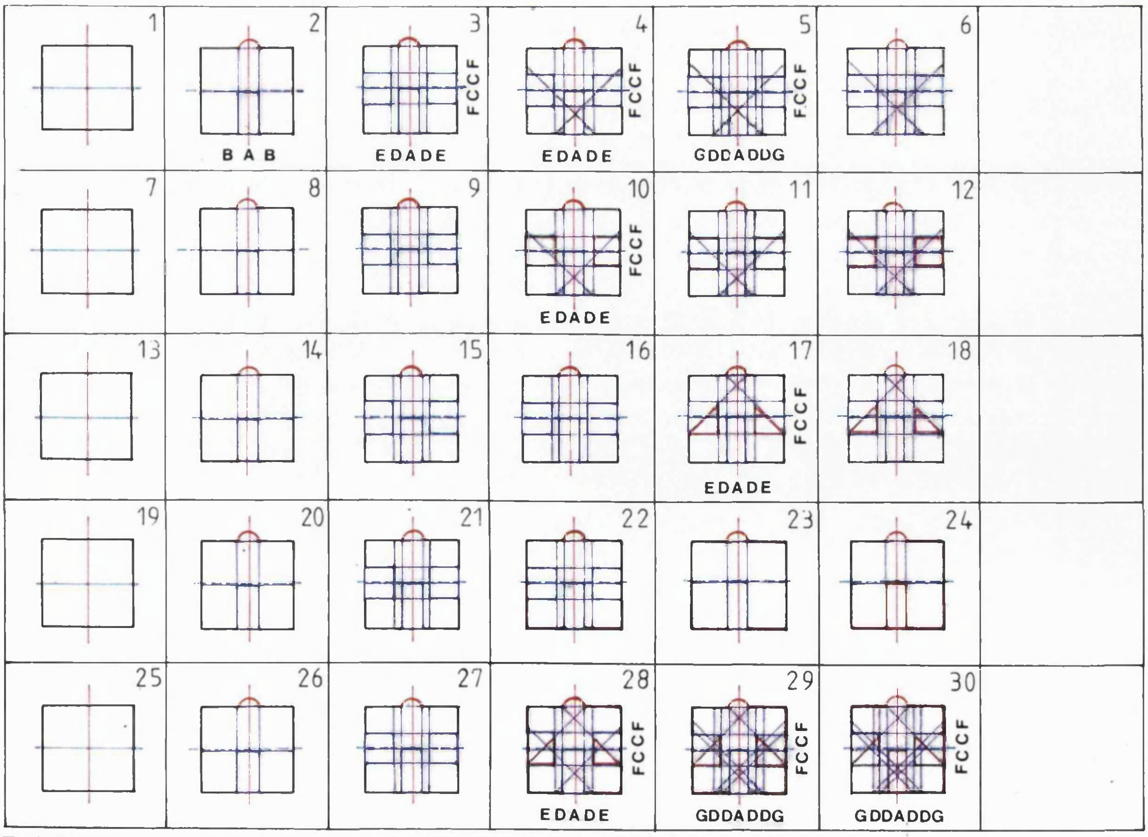



Table **BH2 3.3**
**Grid Geometrical Properties**

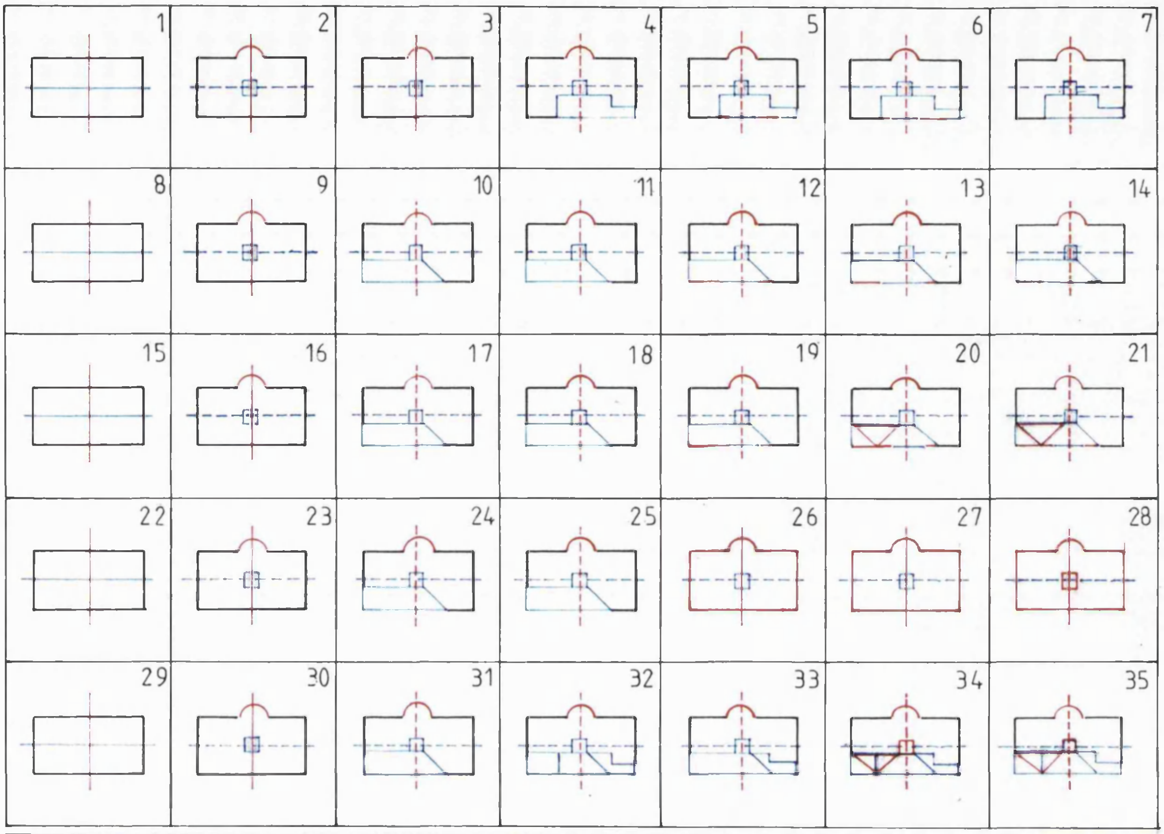


Table BH3 3.2
**Shape Geometrical Properties**

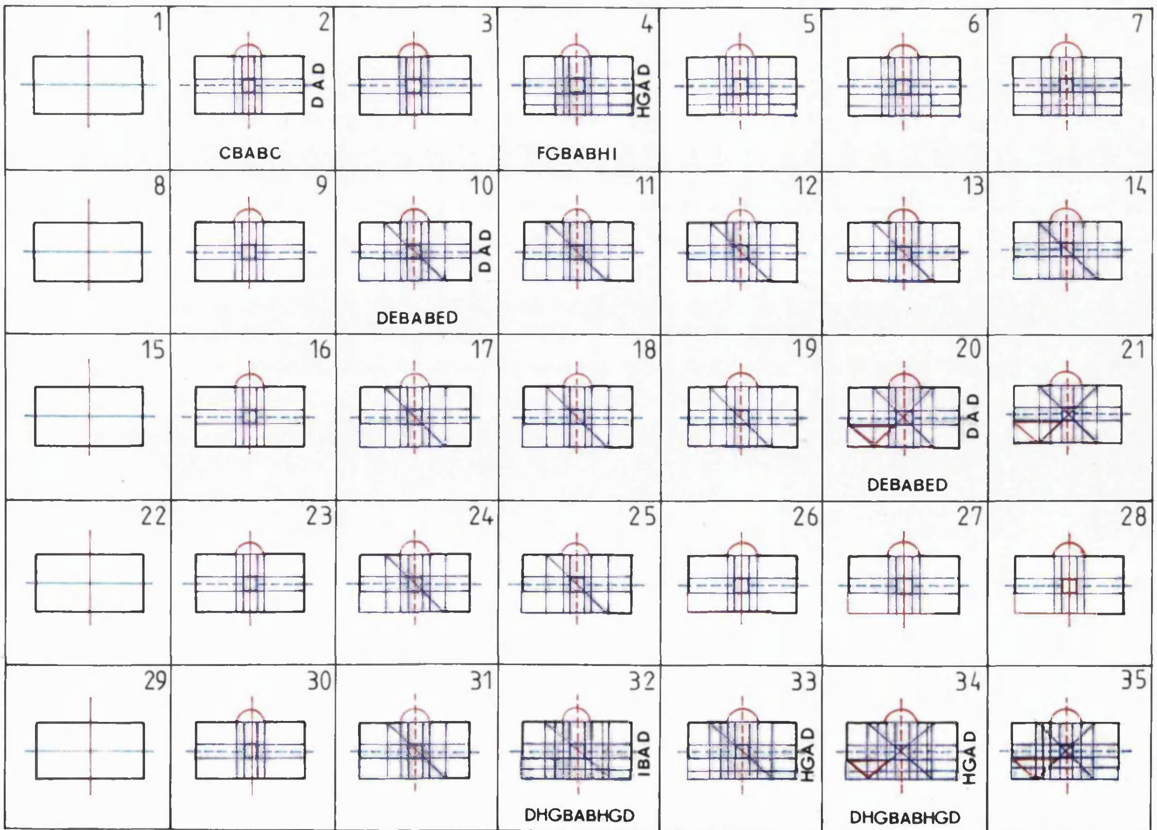



Table BH3 3.3
**Grid Geometrical Properties**

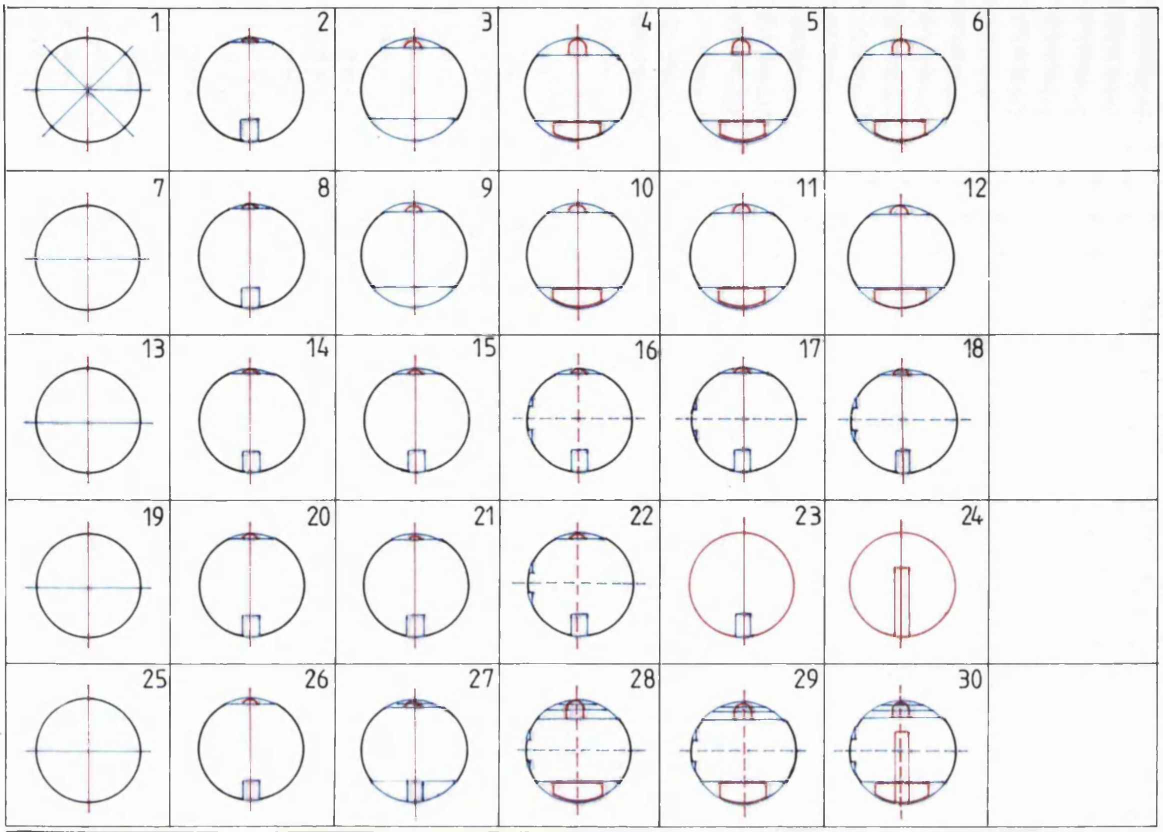



Table **BH4 3.2**
**Shape Geometrical Properties**

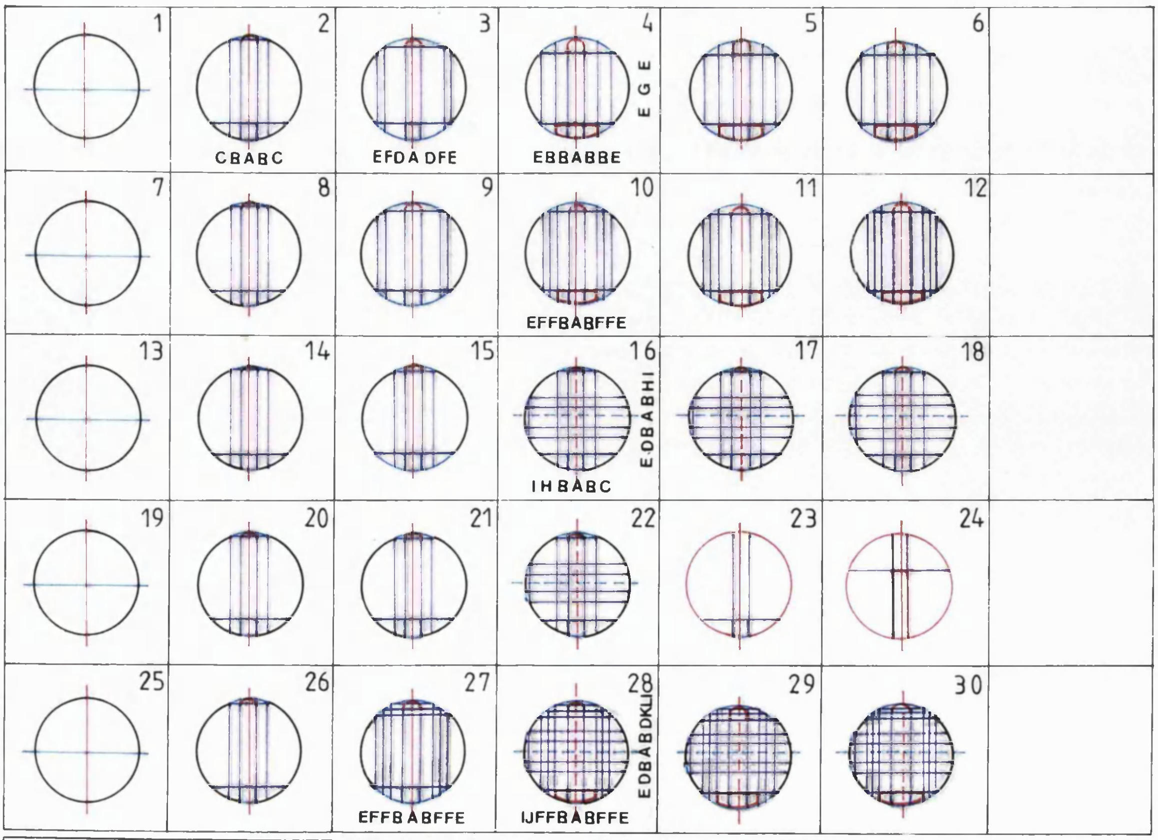
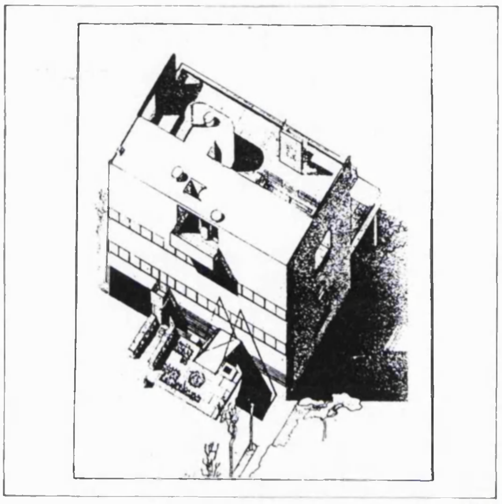



Table **BH4 3.3**
**Grid Geometrical Properties**



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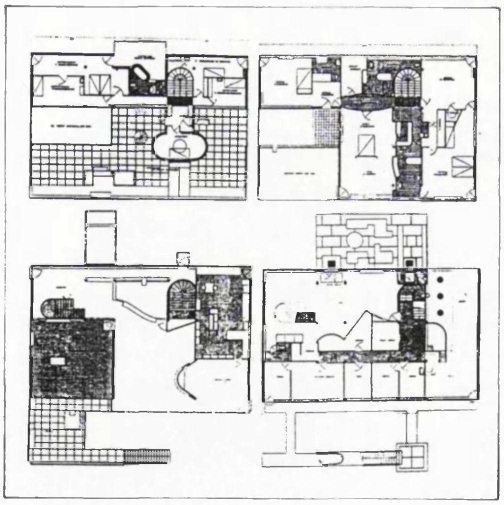

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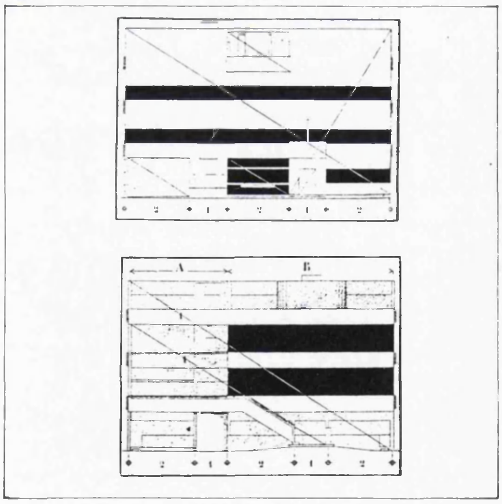


## LE CORBUSIER -VILLA STEIN- (LH1)

### • GENERAL DESCRIPTION, (illustrations 3.30-3.33)

Situated at the suburb of Vaucresson at the west of Paris Villa Stein is the final stage of a series of design proposals which experimented in the location of the house on the site and in the sculpturing of its volume, (illustration 3.30, p. 175). The house divides the site into public and private areas, the former facing the north and the latter facing the south. Like the other early houses of Le Corbusier it exemplifies the five points featuring a columnar support system, free plans, ribbon windows, free facades and a roof terrace.

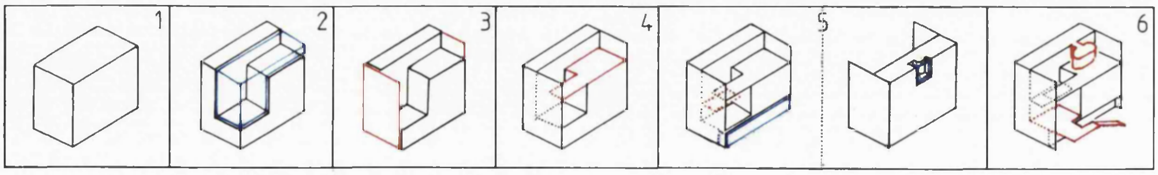
The front elevation is a flat membrane that creates a contrast between the linear extension of the ribbon windows and the symmetrical placement of the opening at the top floor and of the two door entries at the ground floor, (illustration 3.33, p. 175). Formal entry to the house is through a door positioned under a suspended canopy at the right side of this elevation. The door at the left side is a service door placed under a small balcony.

At the back the volume steps down forming a series of terraces that open towards the garden, (illustration 3.31, p. 175). A terrace plane projects outside the perimeter of the house to link the ground with the 'piano nobile'. At the top an elliptical volume protrudes into the third floor terrace. Its curved surfaces contradict the rectangular form of the house.

A vertical slot pierces the side facades from the ground to the top exposing the horizontal division of the volume into four levels and detaching the front plane from the two side planes. A series of openings are centrally placed on these elevations bringing light into the ground floor and exposing the terraces behind, (illustration 3.30, p. 175).

The Villa is developed in four floor levels that are organised according to the classical division of the volume into a 'podium' that accommodates the entry, the garage and the service facilities, a 'piano nobile' housing the day activities and the top floors accommodating the bedrooms with their service areas, (illustration 3.32 a, b, c, d, p. 175).

Table LH1 3.1



- **DESCRIPTION OF STAGES**

At stage one the house is described by a rectangular volumetric block, (TLH1 3.1 fig. 1). This block is symmetrical with respect to two perpendicular axes running through its geometrical centre, (TLH1 3.2, fig. 1, p. 178).

At stage two a volumetric L is subtracted from the block, (TLH1 3.1, fig. 2) The resulting solid is also a volumetric L[25]. The three horizontal surfaces of this solid correspond to the first floor, to the third floor and to the roof terrace of the house.

The volumetric L has the crucial property to provide with horizontal and vertical sections that are different from one another in terms of both shape and geometrical properties. Thus, whereas the geometrical properties of the volumetric U are examined by looking at a single horizontal section, the properties of the volumetric L have to be examined by looking at all sections.

The ground floor section is similar to a section that cuts through the block. Thus, it is symmetrical with respect to the BF and LR axes, (TLH1 3.2, fig. 2, p. 178). The first and second floor sections consist of a planar L and a rectangle, (TLH1 3.2, fig 8, 14, p. 178). The L is not a symmetrical shape. Further, the geometrical axes of the rectangle do not coincide with the geometrical axes of the block. Thus, this section is not organised by symmetry as a whole.

The third floor section consists of three rectangles, (TLH1 3.2, fig. 20, p. 178). Each of them is described by a BF and a LR axis. The BF axis passing from the centre of the longitudinal rectangle coincides with the BF axis of the block. Nevertheless, there is not any symmetrical pattern relating all the axes of the rectangles to each other or to any of the axes of the block[26].

The sections through the second and the third floor as well as the superimposition of all sections are similar when seen as an arrangement of grid lines, (TLH1 3.3, fig. 8, 14, 20, 26, p. 178). This arrangement consists of two geometrical bays from left to right and two geometrical bays from back to

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25 The difference between the solid and the void components is that the former is a volumetric L in three directions whereas the latter is a volumetric L in one direction. This can be demonstrated by looking at sections that cut through the former at three different directions, (fig, 3.8, p. 203). These are a horizontal section, (fig. 3.9, p. 203), two vertical across sections, (fig. 3.10, 3.11, p. 203), and one vertical along section., (fig. 3.12). All these sections are planar Ls. On the other hand, in the latter, (fig. 3.13, p. 203), only the vertical along sections are planar Ls, (fig. 3.14, p. 203).

26 The superimposition of all sections, (TLH1 3.2, fig. 26, p. 178), is not examined separately because it is similar to the third floor section.

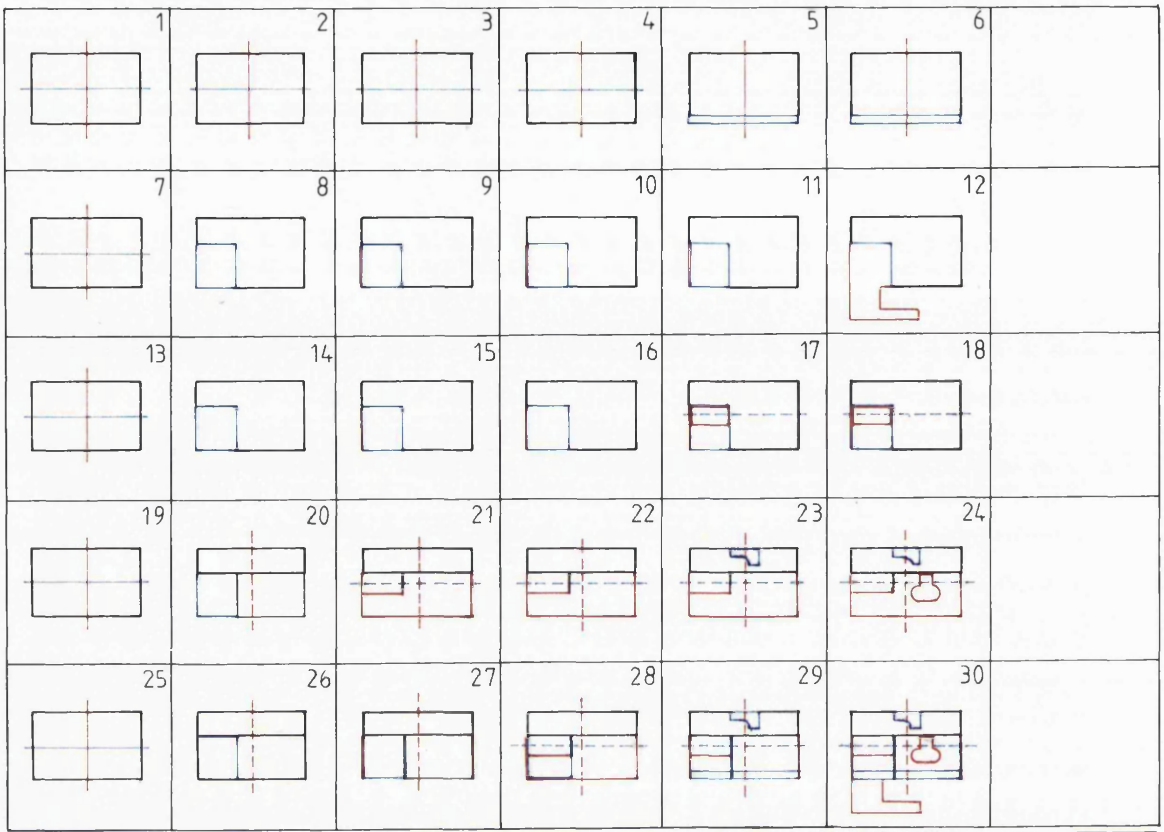


Table **LH1 3.2**
**Shape Geometrical Properties**

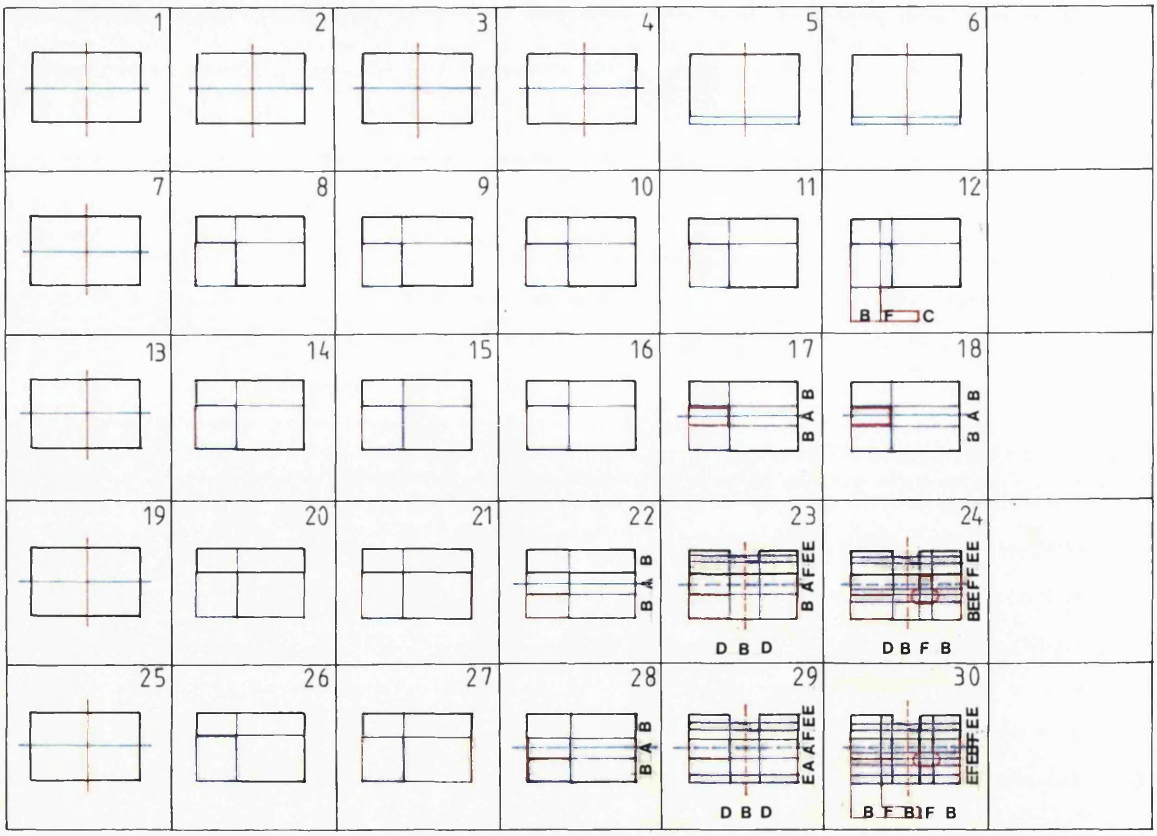


Table **LH1 3.3**
**Grid Geometrical Properties**

front. There is no pattern of geometrical symmetry governing the relations among the lines and the bays of this grid.

At stage three the left and right surfaces of the volumetric L are extended towards the top and towards the front to reach the circumference of the block, (TLH1 3.1, fig. 3, p. 177) There are no changes at the geometrical properties of the shapes or the properties of the grids at this stage, (TLH1 3.2, TLH1 3.3).

At stage four a part of the third floor horizontal surface is extended towards the left and over the first floor terrace, (TLH1 3.1, fig. 4, p. 177). The shape of this surface changes from a rectangle to a planar L.

The third floor section consists of a planar L and of two rectangles, (TLH1 3.2, fig. 22). The BF axis passing from the geometrical centre of the longitudinal rectangle coincides with the BF axis of the block. Besides, the LR axis of the small rectangle on the left coincides with the LR axis of the block. However, there is no overall symmetry governing the disposition of these shapes as a whole. The geometrical organisation of all sections is not characterised by overall symmetry either, (TLH1 3.2, fig. 28).

The geometrical grid consists of three geometrical bays at width that are arranged according to the rhythm: B A B, (TLH1 3.3, fig. 22, p. 178). Thus, the grid is symmetrical with respect to the LR axis passing through the centre of the block. It is also tripartite with respect to the central geometrical bay running from left to right. At length the properties of the grid remain as they are defined at stage two.

Thus, at this stage *the third floor section seen as a combination of shapes is not symmetrical, while seen as a combination of grid elements is characterised by symmetry.*

When the geometrical grids of all floors are examined together, it turns out that the new grid is similar to the grid of the third floor. Thus, it has the same geometrical properties with the ones described before, (TLH1 3.3, fig. 22, 28).

At stage five a horizontal plane is inserted inside the void at the second floor stretching from the left to the right side of the composition, (TLH1 3.1, fig. 5.1, p. 177). A rectilinear volumetric component is subtracted from the base of the volume extending throughout the length of the building. Finally, a volumetric L is subtracted from the third floor at the back of the volume, (TLH1 3.1, fig. 5.2, p. 177).

The section through the ground floor changes from the initial rectangle it has been in all the previous stages to two rectangles, (TLH1 3.2, fig 5). Both shapes are symmetrical with respect to the BF axis of the block.

The second floor section consists of a planar L and of two rectangles, (TLH1 3.2, fig 17). The shape and the grid geometrical properties of this arrangement coincide with the properties of the third floor section described at stage four. Thus, although the BF axis and the LR axis of the block cover the geometrical centres of the longitudinal and the small rectangle respectively, there is no overall symmetrical organisation of the shapes around a single axis. On the other hand the grid is symmetrical and tripartite from back to front, (TLH1 3.3, fig. 22, 17, p. 178) The third floor section is also asymmetrical, (TLH1 3.2, fig. 23, p. 178). Finally, asymmetry characterises also the superimposition of all sections, (TLH1 3.2, fig 29, p. 178).

At the third floor the geometrical bays are arranged at length according to a D B D rhythm. Thus, the grid is symmetrical and tripartite along the BF axis and the BF geometrical bay, (TLH1 3.3, fig. 23, p. 178). From back to front the grid bays are arranged according to the following sequence: E E F A B. There is no symmetry and tripartition along this direction.

When all sections are considered together tripartition and symmetry are retained only at length of the configuration according to the D B D rhythm. At length the B A B sequence defined at stage four is transformed to a E E F A A E sequence, (TLH1 3.3, fig. 29, p. 178).

At stage six a volumetric component consisting of an elliptical and a rectangular volumetric unit is attached to the third floor terrace, (TLH1 3.1, fig. 6, p. 177). Further, a part of the first floor terrace is extended outside the perimeter of the volume. The shape of this plane changes from a rectangle to a planar L.

Both the first and second floor sections seen as a configuration of shapes are asymmetrical, (TLH1 3.2 fig 12, 24, p. 178). The superimposition of all sections lacks overall symmetry also, (TLH1 3.2, fig. 30, p. 178).

The first floor grid consists of three geometrical bays at length and two geometrical bays at width, (TLH1 3.3, fig. 12, p. 178). At length the rhythm of the bays is : B F C. Thus, there is no pattern of symmetry or tripartition governing the relations among the grid lines and the geometrical bays.

The third floor geometrical grid consists of four bays at length that are arranged as following: D B F B, (TLH1 3.3, fig. 24, p. 178). There is no overall symmetrical or tripartite rule relating the geometrical lines and the geometrical bays either. However, there is a tripartite schema that relates three of the geometrical bays located at the right side of the configuration. Thus, although a rule relating all the elements together is lacking, a local rule relating particular elements is applied. At width the grid bay progress according to the ratio defined at the previous stage, i.e. E E F F E E B. There seems to be no symmetrical or tripartite relation along this direction.

Looking at all sections together the configuration of the grid changes, (TLH1 3.3, fig 30, p. 178). From left to right the geometrical bays proceed according to the sequence: B F B F B. This grid is characterised by symmetry with respect to the axis passing from the geometrical centre of the block. Besides, the alternating rhythm of wide and narrow geometrical bays creates three tripartite schemata. Two of these schemata relate the narrow geometrical bays with one of the side bays and the central bay. The other schema relates all bays together marking the difference among the central and the rest of the bays. Thus, at the final stage the asymmetrical organisation of the shapes at the level of the building as a whole, (TLH1 3.3, fig 30, p. 178), is contrasted by the symmetrical organisation of the grids. From back to front the grid is organised according to the following rhythm: E E F F E E F E . Along this direction there is no geometrical symmetry or tripartition.

- **COMPARISON ACROSS STAGES**

- **Physical properties**

The transformation of the volume is carried out by the operations of subtraction, addition and planar extension. At stage two the block looses physical definition of the left and right vertexes at the top as well as of its front horizontal edge, (TLH1 3.1, fig. 1, p. 177). The physical definition of the top side edges as well as of the front and the side surfaces is also reduced. As it was mentioned before the vertexes, edges and surfaces of the block are physical elements that are directly visible determining its physical identity and recognisability as a geometrical solid. When these elements loose their physical definition, the block looses its physical definition also. Thus, the block at stage two is not present.

Planar extension at stage three redefines the two front vertical and the two top horizontal edges of the block, (TLH1 3.1, fig. 2, p. 177). However, only one of the two surfaces defining the two vertical edges and only one of the three surfaces defining each of the front vertexes are physically present.

Thus, the extended surfaces do not fully restore its solid appearance. Further, the volumetric clarity of the solid L is destroyed by the extensions of two of its surfaces. Thus, the planar definition of the block results in a planar decomposition of the solid L. Both the block and the volumetric L are given, thus, volumetric and planar characteristics.

The extended planes define not only the left and the right sides of the block but also the left and the right sides of the void created by the subtraction of the volumetric L at stage two. Thus, the physical elements of the block define both the solid and the void components playing a unifying role that is analogous to the continuous boundary unifying the two spaces in figure. 3.2, (p. 203).

The planar decomposition of the volumetric L is extended at the following stages by the extension of the third floor and the first floor terraces, (TLH1 3.1, fig. 4, 6, p. 177). These terraces together with the terrace added at the second floor, (TLH1 3.1, fig. 5, p. 177), create a horizontal layering of surfaces that starts from the roof and steps gradually down to the ground. These planes reduce the volumetric clarity of the solid L further without affecting the physical definition of the block.

The third floor and the second floor terrace subdivide the open space, into two volumetric components that interlock along the vertical direction, (fig. 3.15, p. 203). Thus, the extended planes destroy the volumetric clarity of both the solid and the void elements created at stage two.

At stage four subtraction is introduced again breaking the physical definition of the two bottom vertexes of the block at the front, (TLH1 3.1, fig. 5, p. 177). Finally, the elliptic component added at the third floor terrace does not change the physical appearance of the block, (TLH1 3.1, fig. 6, p. 177).

The comparative analysis of all stages shows that two types of transformation take place along the analytic sequences. The first one decomposes the block by neglecting the rules that describe it as a physical object. The volume in progress maintains no connection with the first state. On the other hand, the second type of transformation reinstates these rules and adapts the volume to fit the requirements of the first stage. These two modes of transformation are alternatively employed resulting in an alternating association/dissociation of the volumes with the initial solid.

Besides, a mutual physical definition amongst the block, the volumetric L and the secondary voids is constructed in a way that preservation of the former is based on adjustments applied to the latter. The complementary relations among the components result in a complex system in which the volumetric clarity of the elements is destroyed and replaced by a network of interpenetrating solids, voids and planes.

- **Geometrical properties**

Analysis of the shape geometrical properties shows that the transformation of the block creates asymmetrical configurations on the level of each individual floor as well as on the level of the volume as a whole[27]. Thus, from stage one to the following stages the volume moves from geometrical symmetry to asymmetry, (TLH1 3.2, fig. 1-30, p. 178).

Analysis of the grid geometrical properties shows that at the first stages the grids are also asymmetrical. However, at the final stages symmetry and tripartition are employed organising certain floor levels. Thus, the second floor grid at stages five and six, (TLH1 3.3, fig. 17, 18, p. 178), and the third floor grid at stage four are symmetrical and tripartite from back to front, (TLH1 3.3, fig. 22, p. 178). Further, the latter at stage five is symmetrical and tripartite from left to right, (TLH1 3.3, fig. 23, p. 178). The asymmetrical organisation of the rest of the levels shows that the individual floors are treated as independent systems each of which exhibits its own properties.

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27 The ground floor is an exception being constantly symmetrical along both axes of the block at the first four stages. At stages five and six it is symmetrical only along the BF axis.

The superimposition of all sections moves also from asymmetry to symmetry. Thus, whereas at the first stages the grid is asymmetrical, at stage four it becomes symmetrical and tripartite from back to front, (TLH1 3.3, fig. 28, p. 178). At the following stage symmetry and tripartition at width are broken and replaced by symmetry and tripartition at length of the configuration, (TLH1 3.3, fig. 29, p. 177). Finally, at stage six they are introduced again governing the configuration from left to right (TLH1 3.3, fig. 30).

Thus, the geometrical organisation of this house seen as a configuration of shapes is asymmetrical. In contrast seen as a grid configuration is symmetrical. Symmetry of the grid structure is established at the final stages through the small scale articulation.

Nevertheless, symmetry of the superimposition of grids is set in contrast either with the asymmetrical organisation of particular floors, or with their symmetrical organisation along a different axis. Thus, at stage four symmetry of the 'all lines' grid is contradicted by asymmetry of the first and second floor grids, (TLH1 3.3, fig 28/ 10, 16, p. 178). Besides, the symmetrical ordering of the former at stages five and six is contrasted with the asymmetrical ordering of the first floor, (TLH1 3.3, fig 29/11, 30/12, p. 178). Further, symmetry and tripartition of the grid of all sections along the left to right direction is contradicted with symmetry and tripartition of the second floor operating along the back to front direction, (TLH1 3.3, fig, 29/17, 30/18, p. 178).

Thus, distinctions occur not only between separate floor levels but also between the grid of the building as a whole and the grids of the floors. The symmetry/asymmetry opposition and the independent treatment of the various systems show that there is not a single principle that is hierarchically applied from the beginning to the end of the analytic sequences.

This opposition characterises also the relationship between the shape and the grid geometrical properties creating a dissociation between the two levels of properties. Obvious shape symmetries are, thus, negated and replaced by grid symmetries that are less easy to observe. However, the independent organisation of each floor grid and its differentiation from the organisation of the grid of the building as a whole disturbs a three dimensional integration of symmetry even at the level of grid properties. This symmetry arises only when all the layers are superimposed one at the top of the other. Thus, looking at the drawings of this building one has to work systematically and extensively with layers of all the floor systems in order to build an understanding of the geometrical properties. Looking at the building in reality this understanding becomes also a matter of an extended inspection that carefully studies the grids generated by asymmetrical elements belonging to different horizontal layers. The decipherment of their underlying logic requires a careful observation and an eye that moves along the surfaces of the volume imagining the continuation of lines and trying to organise them into an overall pattern.

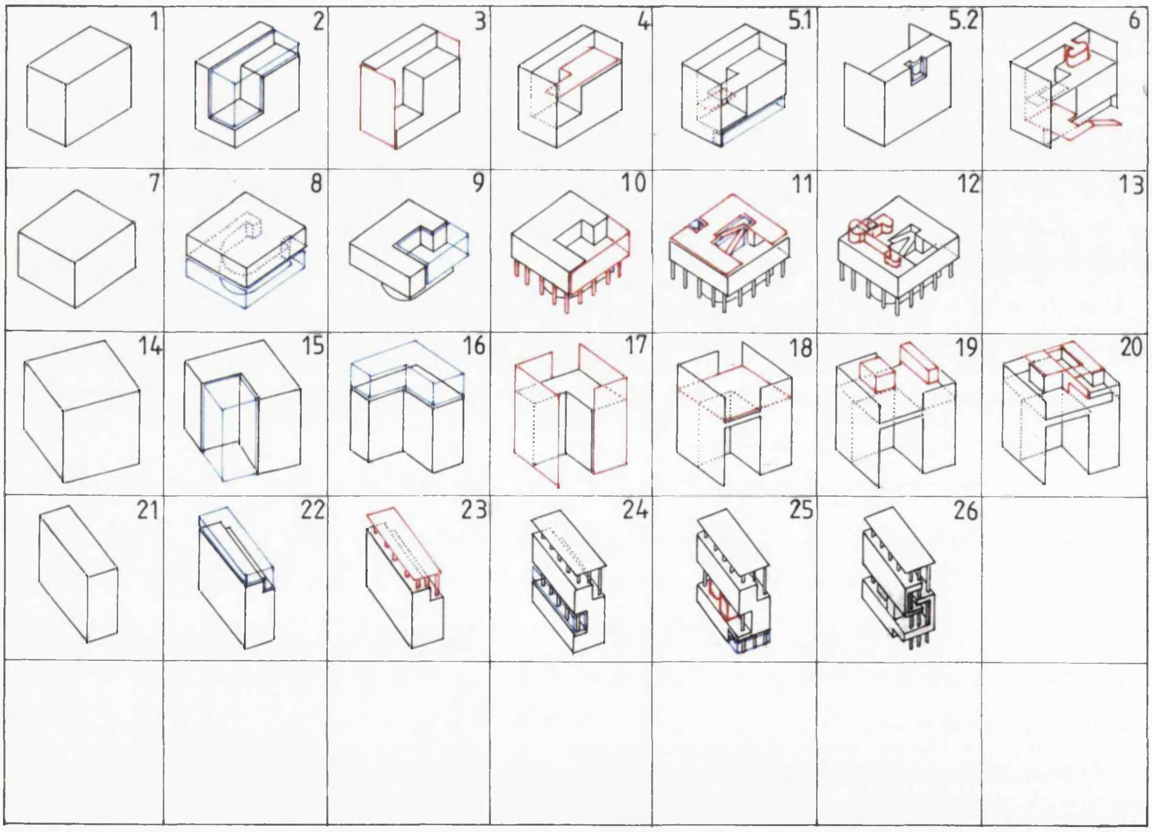


Table L 3.1

## • COMPARISON ACROSS LE CORBUSIER'S HOUSES

This part of the analysis examines all four houses of Le Corbusier comparatively. The aim is to identify any similarities and differences amongst them that can lead to a better understanding of the questions set at the beginning of this chapter. The comparative approach tries also to answer the same questions with the ones it sets at the comparative analysis of Botta's houses. These are the following:

- Is there any pattern governing the transformation of the volume along the analytic sequences?
- Which are the rules that govern the transformation process?

### THE PATTERN OF THE TRANSFORMATION PROCESS

- **Operations and their order of occurrence**

Analysis shows that the simplest volumetric concept that describes these houses is a single block, (TL 3.1, fig. 1, 7, 14, 21). This block is symmetrical according to two perpendicular axes that pass through its geometrical centre and traverse it at length and at width.

At the following stages these blocks are transformed by volumetric subtraction, volumetric and planar addition and planar extension. Table LH-S, (p. 184), locates subtraction in relation to the stages for each individual house. Thus, this operation starts in all houses at stage two, (TL 3.1, fig 2, 8, 15, 22) and continues also at stages three, four and five, (TL 3.1, fig 5.1, 5.2, 9, 11, 16, 24, 25). Looking at the table it turns out that there is a consistent pattern of occurrence which associates subtraction always with stage two, mostly with stage five and partly with stage three.

Tables LH-A and LH-E, (p. 184), locate addition and extension in relation to the relevant stages in all houses. These tables show that volumetric and planar addition occur at the middle and last stages in most of the houses, (TL 3.1, fig. 5.1, 6, 12, 19, 25). Planar extension is used mainly at the middle and final stages of the analysis also, (TL 3.1, fig. 3, 4, 6, 11, 17, 18, 19, 20, 23). Thus, there seems to be a consistency associating addition with stages five and six and extension with stages four, five and seven.

Finally, table LH-SAE, (p. 184), locates all operations in relation to the equivalent stage for each house. Looking at the patterns of relations among these operations it seems that subtraction addition and extension alternate along the sequences. Therefore, there seems to be also a consistent pattern governing the order of occurrence of these operations in relation to each other.

The transformations that these operations cause are the following:

Subtraction at stage two excavates the sides of the block creating a large void, (TL 3.1, fig. 2, 8, 15, 22). Planar extension extends the outer surfaces of the largest volumetric component to reach the edges of

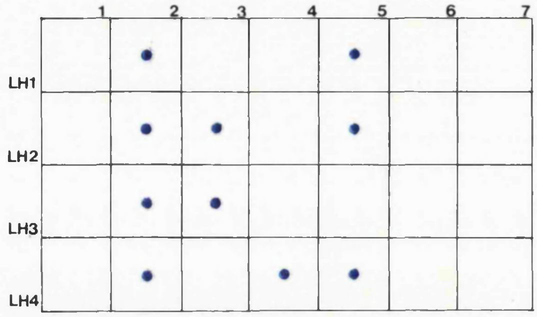


Table LH−S Subtraction

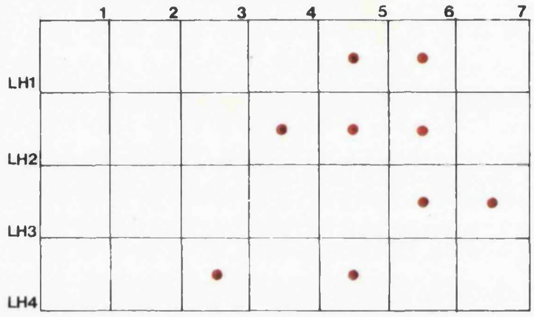


Table LH−A Addition

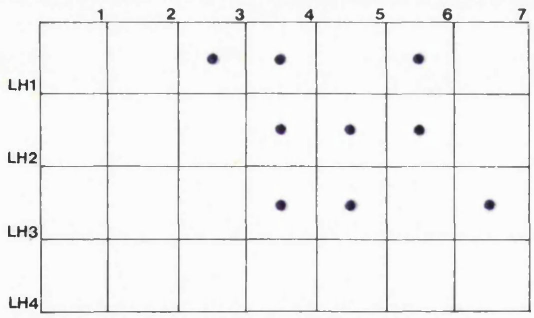


Table LH−E Extension

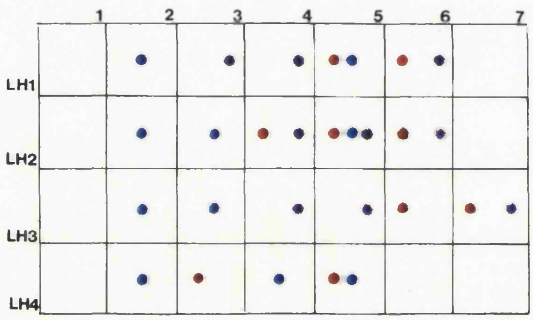


Table LH−SAE

the block[28], (TL 3.1, fig. 3, 10, 17, p. 183). Subtraction either excavates the sides creating a second or a third void, (TL 3.1, fig. 9, 11, 24, p. 183) or the top, (TL 3.1, fig. 16, p. 183), or the bottom of the volume, (TL 3.1, fig. 5.1, 8, 25, p. 183). Planar extension extends the surfaces of the volumetric component resulting from subtraction and subdivides the initial void into sub voids, (TL 3.1, fig. 4, 18, p. 183). Finally, planar extension and addition subdivide the initial or the smaller voids, (TL 3.1, fig. 5.1, 20, 25, p. 183).

Thus, there seems to be a certain course in the transformation process. This starts with subtraction. Then it proceeds with extension that redefines the extreme elements of the block. At the following stage subtraction is introduced again excavating the volume further. Finally, at the last stages extension and addition subdivide the open spaces into secondary voids.

The employment of a specific pattern of transformation reveals that there is an underlying logic governing the types of operations, their order of occurrence and the changes they produce to the volumes at each stage. *This seems to suggest that there is a certain course of action the architect intentionally employs in the ways he transforms and shapes his design elements.*

However, analysis shows that in spite of this course of action there are no predetermined ways the physical appearance of the volumes is structured. This is something that the comparative examination of the shapes used and of their rules of combination will demonstrate.

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28 Planar extension does not occur in LH4. In this house the edges of the block are redefined by a canopy supported on a grid of columns, (TL 3.1, fig. 22, 23, p. 183).

## • THE RELATIONAL LOGIC OF TRANSFORMATION

### • Types of shapes and types of combinations

At stage two the shape of the subtracted component is different from house to house. In Villa Stein a volumetric L is subtracted resulting in a solid L in three directions[29], (TL 3.1, fig. 2, p. 183). In Villa Savoie a curvilinear element is cut off from the ground floor creating a horizontal division of the block into a curvilinear and a rectangular volumetric component, (TL 3.1, fig. 8, p. 183). In Villa Meyer a volumetric rectangle is subtracted resulting in a volumetric L in one direction, (TL 3.1, fig. 15, p. 183). In Villa Baizeau a vertical volumetric L is removed creating a solid L in one direction also, (TL 3.1, fig. 22, p. 183).

However, regardless of the apparent differences in the volumetric appearance of the resulting solids there seems to be a consistency regarding a general *type of shapes* these solids belong to. This type refers to the volumetric L that takes different forms in each case resulting in volumetric Ls in one, or three directions. Thus, *there is rather a recurrent type of shape than a particular shape that is employed in every house.*

There seems to be also a consistency regarding the position of the void that is created by subtraction. Although excavation occurs in different locations, the subtracted unit is always taken from the edges of the block. Thus, the void opens towards more than one sides.

*Thus, there is a tendency that favours the consistency of a type of shape and of a type of combination, while at the same time allowing for differentiation in size, proportions and location of the subtracted unit. This results in volumetric objects that have not identical appearances but they are similar in terms of the type of the shapes used and the type of their relationship.*

The subtracted solids at the following stages are either volumetric rectangles or volumetric Ls. Thus, in LH1 the subtracted solids are a rectilinear rectangle and a curvilinear L, (TL 3.1, fig 5.1, 5.2, p. 183). In LH2 they are two volumetric Ls, (TL 3.1, fig 9, 11, p. 183) and a volumetric rectangle, (TL 3.1, fig 11, p. 183). In LH3 the subtracted solid is a volumetric L, (TL 3.1, fig 16, p. 183), and in LH4 it is a rectilinear volume, (TL 3.1, fig 24. p. 183), and a curvilinear L, (TL 3.1, fig 25). Thus, the use of these two shapes is favoured at the other stages also. Similarly to the solid removed at stage two, these solids are subtracted from the sides of the volume creating voids that open towards more than one direction[30].

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29 Analysis defines as three directional L the volumetric L that provides with horizontal, vertical across and vertical along sections that are all planar Ls, (fig. 3.8 - 3.12, 3.23-3.25, p. 203) An one directional L gives sections that are planar Ls only along a single direction, (fig. 3.13, 3.14, p. 203).

30 The void at the front facade of Villa Stein and the void at the left side of Villa Savoie are exceptions opening only towards one side of the volume, (TL 3.1, fig 5.1, 11, p. 183).

*Thus, it seems that there is a certain design logic the architect intentionally employs consisting not only of certain procedures and order of operations but also of a certain vocabulary of shapes and shape permutations. However, this vocabulary comprises a broad class of shapes and a broad class of combinations allowing for individual variation in figurative appearance of shapes from one house to the other.*

- **RULES OF COMBINATIONS**

- **Physical properties**

Analysis showed that subtraction and planar extension are alternatively applied during the transformation process, (TLH-SAE, p. 184). The examination of each house suggested that the former decomposes the initial solid, whereas the latter restricts and directs the process of making creating a connection with the first stage. The recurrent shapes and their combinations seem to play an important role in this alternative differentiation and association between the volume in process and the initial solid. To explain which this role is, analysis looks at these two operations in relation to the changes they produce.

- **Subtraction**

Subtraction of a volumetric component from the sides of the block results in a volumetric L, (TL 3.1, fig 2, 9, 15, 22, p. 183). This element does not preserve the property of each surface of the block to intersect with two of the other surfaces to construct eight concave vertexes and twelve concave edges that are all physically defined. Two or more vertexes of the block are not physically present. Besides, some of the surfaces do not intersect with each other, whereas others intersect but not in full length. Further, there is at least one convex edge as opposed to the block that has only concave edges. Thus, the physical properties of the resulting solid are different from the physical properties of the block. The initial solid is not preserved loosing its recognisability as a volumetric concept.

- **Planar extension**

Extension of the outer surfaces of the volumetric L results in planes that reach the edges of the first volume, (TL 3.1, fig. 3, 10, 17, p. 183). This operation provides with a certain degree of physical definition that links the volume with the initial state.

The alternating occurrence of these two operations shows that the process of transformation oscillates between a preservative mode and a obliterative mode. At one stage the object moves away from its origins and at the next stage it comes back re-establishing the links with its initial condition. Thus, the rules leap across the previous stage to establish a connection with the first stage.

There is a second dimension to planar extension regarding the transformation it causes to the volumetric L. What it does is to adjust this solid changing particular edges from concave to convex and stretching particular surfaces outside its perimeter. The extended planes increase the physical definition of the block by changing the physical properties of the sub-solids. *Thus, the relationship between the block and the volumetric L becomes complementary. The definition of the one results in the decomposition of the other.*

However, analysis suggested that planar extension does not completely restore the physical elements of the block. In LH1 and LH3 the extended planes feature as screens that do not intersect with each other to form solid vertexes and give the initial volume its complete volumetric appearance. At the same time, they deform the volumetric L into a combination of volumetric and planar parts. The two volumes merge together in a constant state of mutual interconnection in which the surfaces of the latter reach out to define the former and recede back to group themselves into their original condition.

The extension of the planes redefines also the voids enclosing them inside the outer perimeter of the volume. Thus, the block, the solids and the voids are defined by common boundaries in a mode that is similar to the continuous boundary presented in figure 3.2, (p. 203).

The extension of the planes in LH2 restores most of the physical elements of the first floor volume reinforcing the clear distinction between the two volumetric components created at stage two, (TL 3.1, fig. 10, p. 183). In this case planar extension contributes rather to the definition of a sub-solid than to the definition of the block. Besides, unlike the other houses where the extended surfaces are read as planes, in this house the volumetric appearance of the redefined component is fully restored at the outside. However, like the previous houses, this restoration is achieved by the decomposition of the solid element defined at stage three.

In LH4 the role of planar extension is substituted by addition of the structural frame supporting a roof plane, (TL 3.1, fig. 23, p. 183). The structural frame appears also in LH2 attempting a redefinition of the block, (TL 3.1, fig. 10, p. 183). However, physical definition provided by columns seems to be weaker than physical definition provided by surfaces for the following reasons:

The columns cannot achieve full physical definition of a side. Besides, their placement does not follow always the outline of the block. Certain rows of columns are placed at a slight distance from the outer surfaces of the volume.

The introduction of the columns reveals an analytic tendency that decomposes the block and the sub-solids into a series of elements so that they no longer register as clear three dimensional components. Thus, planar extension and columnar addition give the volumes planar and columnar readings.

At the following stages subtraction reduces the physical definition of the block further. Addition and extension also continue the transformation of the volume without producing major changes to the physical condition of the initial solid. Analysis identified that through these transformations a series of changes takes place mainly oriented towards the articulation of the void defined by subtraction at stage two. Thus, in LH1 the open space is subdivided in a way that two interlocking voids are defined in section, (fig 3.15, p. 203). In LH2 it is enlarged resulting in an interlock relationship between a solid and a void component in plan, (fig, 3.16, 3.17, p. 203). In LH3 it is subdivided creating an interlock between two solids and a void in plan, (fig. 3.19, 4.20, p. 203). In LH4 the first floor terrace is subdivided resulting in an interlock between a solid and a void element, (fig. 3.22, p. 203). Interlock is also created between the solid and the void components at the ground floor, (fig. 3.21, p. 203).

This transformation of the open space into interlocking constituents creates an inter - penetration of elements that no longer sustains the geometrical clarity of the initial element they stem from. Besides, it is not only the open space that becomes complicated loosing its initial shape. It is also the elements into which it is analysed that interpenetrate fastened together in a defiance of their individuality and distinctiveness as lucid geometrical shapes.

These elements are defined by the extended surfaces that are stretched to restore the block. Thus, the external side of these surfaces reaches out to redefine the block whereas its internal side participates into the intricacies of an interlace between solids, voids, and planes. The block and the secondary elements enter into complementary relations. A multilayered planning of interwoven structures is created that register towards all possible directions never achieving a clear and explicit grouping of contours into distinct three dimensional units.

- **PHYSICAL PROPERTIES AND INTELLIGIBILITY**

The comparative analysis of the physical properties of the volumes shows that the transformation process does not consistently preserve the physical properties of the block. It alternatively neglects and applies these properties resulting in the deformation of the volume into a complex set of volumetric elements. These elements are mutually defined by common boundaries. Thus, they become interdependent producing a structure that cannot register towards a simple volumetric concept as clearly and simply as the block does.

- **GEOMETRICAL PROPERTIES**

- **Shape geometrical properties**

Analysis identified that along the analytic sequences the volume in process moves from symmetry to asymmetry. However, symmetry is not completely abolished operating mainly at the first stages.

In LH2, LH3 and LH4 the distribution of particular volumetric components is controlled by one or more axes of the block[31]. More particularly, LH2 is symmetrical as a whole along the BF axis at stage two, (TLH2 3.2, fig. 20, p. 198). LH3 is symmetrical along the diagonal axis from stages two to five, (TLH3 3.2, fig. 30 - 33, p. 200). Finally, LH4 is symmetrical with respect to the BF axis at stages two and three, (TLH4 3.2, fig. 26, 27, p. 201), and symmetrical with respect to both axes at stage four, (TLH4 3.2, fig. 28, p. 201).

However, as analysis showed, the organising principles of the volumes as wholes are contrasted with the organising principles of each individual level. This contrast operates along two directions. It is articulated either between an overall asymmetry and symmetry on the level of individual floors, (TLH2 3.2, fig. 21-24/2-6, p. 198), (TLH1 3.2, fig. 26-30/2-6, 197), (TLH3 3.2, fig. 34, 35/6-7, 13-14. p. 200), (TLH4 3.2, fig. 29, 30/17-18, 23-24, p. 201), or between an overall symmetry along one axis and symmetry of the floor levels along both axes, (TLH2 3.2, fig. 20/8, 14, p. 198), (TLH4 3.2, fig. 26, 27/2, 8, 14, 3, 9, 15, p. 201).

Analysis suggested that the contrast between the overall arrangement and each individual floor shows that there is not a single rule that is applied hierarchically to every horizontal level. Lack of hierarchical geometrical organisation articulates a geometrical division of the volume into separate individual systems. This division disrupts a three dimensional integration of the floors around a single organising principle creating a system that oscillates between symmetry and asymmetry as well as between one co-ordinating axis and another.

The negation of bilateral symmetry of the final product as a whole reveals a tendency that questions the geometrical organisation of the initial volume with its apparent simplicity of axial symmetries. The adoption of symmetries at the first stages, however, shows that the volume in process is not completely released from the control of the geometrical axes of the block. Thus, like the physical ordering, the geometrical ordering of the houses is twofold: on the one hand, it regulates the volumes to abide with the geometrical properties of the largest volumetric component, while on the other it frees them from its obvious axial symmetries.

However, unlike the transformation of the physical properties which first dissociates the volume from the block and then establishes a link with the initial state, the transformation of the geometrical properties co-ordinates first the axes of the volumes with the axes of the block and then it discards co-ordination allowing the volumes to move away from symmetry. Thus, symmetry articulates relations among the largest volumetric components, while asymmetry is introduced by the articulation of the small scale. This seems to suggest that the architect offers some means of obvious and direct intelligibility based on symmetry of the largest volumetric component.

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31 LH1 is not symmetrical as a whole in any stage.

- **Grid geometrical properties**

Analysis of LH2 and LH4 distinguishes between two different systems of geometrical grids. One is the physical grid generated by the extensions of the lines defining the shapes, (TLH2 3.3, p. 199, TLH4 3.3, 202), while the other is the structural grid constructed by the extensions of lines passing through the geometrical centres of the columns, (TLH2 3.4, p. 199, TLH4 3.4, p. 202). Analysis looks at these two grids in separation as well as in relation to each other[32].

- **Physical grids**

Analysis shows that the geometrical organisation of the grids of the houses at the level of the building as a whole employs both symmetry and asymmetry. It also employs tripartite and non tripartite relations among a central bay and a set of side bays. It also shows that there is no consistent pattern governing the occurrence of symmetry and tripartition along the analytic stages. Thus, in LH1 these rules occur at the final stages, (TLH1 3.3, fig. 29, 30, p. 197). In LH2 they appear in every stage, (TLH2 3.3, fig. 20-24, p. 199). In LH3 it is only symmetry that is employed operating along the diagonal axis of the block at the first and middle stages, (TLH3 3.3, fig. 30-33, p. 200). Finally, in LH4 symmetry and tripartition are employed only at stage four, (TLH4 3.3, fig. 28, p. 202).

Therefore, in LH1 symmetry and tripartition of the house as a whole is introduced by the small scale articulation occurring at the final stages of the analysis. In LH2 they govern both the large and the small scale properties featuring in all stages. In LH3 symmetry organises relations among the largest volumetric components of the first and the middle stages. Finally, in LH4 they co-ordinate relations among large volumetric elements introduced at the fourth stage.

- **Structural grids - Houses LH2 and LH4**

The structural grids mainly consist of a set of equal geometrical units that are repeated at length and width, of the configuration, (TLH2 3.4, fig. 4, p. 199), (TLH4 3.4, fig. 8, p. 202).

- **Relationship between the structural and the physical grids**

The structural grid with its apparent homogenous character of equal geometrical intervals contrasts either the hierarchical tripartite organisation or the asymmetrical organisation of the physical grid. Thus, the two grids are treated as autonomous arrangements each of which exhibits its own properties.

*This clarifies and enriches the notion of the 'free plan' often described as a mere detachment of partitions and columns or as a mere contrast between an ordered orthogonal system and a free arrangement of*

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32 Tables TLH2 3.4, p. 199 and TLH4 3.4, (p. 202), present both the structural and the physical grid. Structural grid lines are distinguished from physical grid lines through colour use. Thus, the former are represented in green colour, while the latter in purple.

*undulating walls. This analysis shows that columnar and planar elements are freed from each other not only as physical objects but also as logical geometrical systems.*

*Thus, it is suggested that the notion of the free plan is not about a rule-free arrangement of walls within the ordered format of the columns. It is about two geometrical systems governed by different properties.*

The superimposition of the physical grids of all horizontal levels and of the structural grid is governed by symmetry and tripartition in every analytic stage, (TLH2 3.4, fig. 10-12, p. 199), (TLH4 3.4, fig. 26-30, p. 202). Thus, although the two geometrical grids are autonomous and different from each other in principle, they merge into a single pattern.

To understand how this simultaneous independence and co-ordination is achieved analysis looks at fig. 11 in TLH2 3.4, (p. 199), and fig 28 in TLH4 3.4, (p. 202). In the former the sequence of the grid bays from left to right can be read as following: C B G F F G B C. It can also be read as : D D D D if the two narrow bays on either side of the grid are considered as a single bay and each of the narrow central bays is combined with the wide bay on its side. The first sequence is the sequence of the physical grid. The second one is the sequence of the bays of the structural grid.

In the second figure the grid bays are arranged according to a B D B B D B rhythm. They are also arranged as a B A A B rhythm when each of the two narrow central bays is joint with the wide bay on its side into a single bay. The fist rhythm is the rhythm of the structural grid, whereas the second one is the rhythm of the physical grid.

*Thus, it seems that the large system resulting from the superimposition of all grids is organised in a way that secondary systems are embedded in it allowing the lines to group themselves into two different patterns.*

Secondary systems are also produced within this large system that correspond to the physical grids of particular floors. These systems articulate a contrast between the large system and themselves expressed as a contrast either between a symmetrical and tripartite grid along both directions, and a symmetrical and tripartite grid along one direction, (TLH2 3.4, fig. 10, p. 199)/(TLH2 3.3, fig. 4, 10, 16, p. 199), or a symmetrical and tripartite grid along one direction and an asymmetrical and tripartite grid, (TLH2 3.4, fig. 11, 12, p. 199)/(TLH2 3.3, 11, 17, 12, 18, p. 199)[33], or between a symmetrical and tripartite grid and an asymmetrical and non tripartite grid, (TLH2 3.4, fig. 29, 30, p. 199), (TLH2 3.3, fig. 11, 12, p. 199).

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33 The dash between the two figures indicates the distinction between an symmetrical grid on the left and an a symmetrical one on the right.

Besides, the autonomous treatment of various systems emerges when the superimposition of the structural grid with the physical grids of all sections is examined in relation to the superimposition of the structural grid with the physical grid of each horizontal level. It also occurs at the other two houses expressed as a contrast between the organisation of the grids of all sections and the organisation of particular floor levels. This autonomy operates along an opposition of symmetry/asymmetry and of symmetry and tripartition along one direction/symmetry and tripartition along another direction.

Thus, overall symmetry and tripartition from back to front or from left to right is opposed either with lack of these principles on the level of some floors, (TLH1 3.3, fig. 29/11, p. 197), (TLH2 3.3, fig. 23/11, 17, 24/12, 18, p. 199), (TLH2 3.4, fig. 11/5, 8, 12/6, 9, p. 199), (TLH4 3.4, fig. 29/11, 30/12, p. 202), or with symmetry and tripartition operating along a different or along both directions, (TLH1 3.3, fig. 28/4, 29/17, 30/18, p. 197), (TLH2 3.3, fig. 21/9, 15, 22/10, 16, p. 199), (TLH4 3.4, fig. 26/2, 8, 14 27/3, 9, 15, 29/23, 30/24, p. 202). There are also cases where lack of overall symmetry is contrasted with symmetry and tripartition of certain horizontal floors, (TLH1 3.3, fig. 26, 27/2,3, p. 197), (TLH3 3.3, fig. 35/7, 14, 28, p. 200).

This seems to show that there is not an hierarchical application of a single rule that is applied in every grid, in every horizontal level and from the largest to the smallest volumetric component. There are more than one set of rules resulting in more than one way the elements are grouped together. They can register towards one axis, while at the same they are held within an overall framework that registers towards another. They can also belong to classes of elements that are asymmetrical, while at the same time belonging to larger classes that are governed by symmetry.

- **Relationship between the shape and the grid geometrical properties**

The opposition between symmetry and asymmetry operates not only on the level of the shape geometrical properties but also on the level of the properties of the grids. However, symmetry of the organisation of shapes is confined at the scale of the large volumetric components. On the other hand, symmetry of the geometrical grids becomes a final statement of the organisation of the building as a whole.

Thus, it seems that a dissociation between the two kinds of properties is created[34]. There seems to be an intentional approach that questions the obvious and directly observable symmetries of the shape arrangement favouring a subtler and hidden order of their regulating lines. These lines operate as an underlying canvas that stays at the background without manifesting itself.

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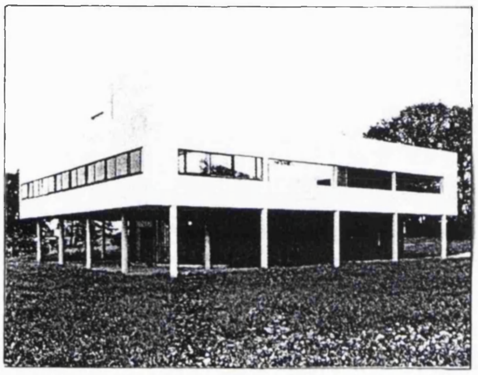
34 LH3 is the only case where properties of the grids and properties of the shapes coincide organising only the large volumetric components of the first and middle stages, (TLH3 3.2, fig. 1-19, 22-26, 29-33, p. 200), (TLH3 3.3, fig. 1-19, 22-26, 29-33, p. 200).

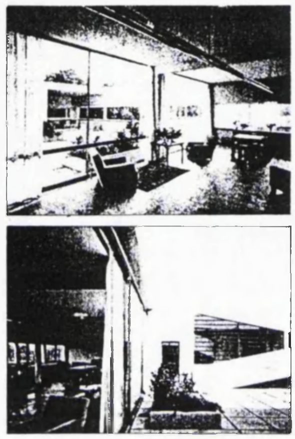
## • GEOMETRICAL PROPERTIES AND INTELLIGIBILITY

Regardless of the implicit order of grids with its overall symmetries, the employment of a multilayered, multifaceted organisation that establishes separation and overlap between its various layers of systems disturbs a three dimensional integration of these layers into a single organising principle.

Thus, the three dimensional subordination of the smaller systems into the larger organisation is not evident in the external volumetric appearance of the house. The clearest example is the symmetrical grid emerging from the superimposition of the third and first floor grids in LH1 where the lines of the elliptical studio at the third floor are co-ordinated with the lines of the terrace of the first floor to define the B F B F B rhythm, (TLH1 3.3, fig. 30, p. 197). This rhythm is not evident at a single glance first because it is disrupted by the lack of identical appearances of the elements it springs from, (the terrace and the studio) and second because it is created by elements belonging to different floor levels.

Thus, it turns out that the underlying complexities of the geometrical properties of these houses create underlying difficulties in the understanding of their relational logic. To understand the structure of the grids one has to imagine the extension of lines in order to classify elements and grasp the three dimensional co-operation of systems. These systems pull themselves from the global pattern into their own groupings in a constant tension of submission and independence that never resolves itself into a simple and clear statement about a single three dimensional organising pattern.





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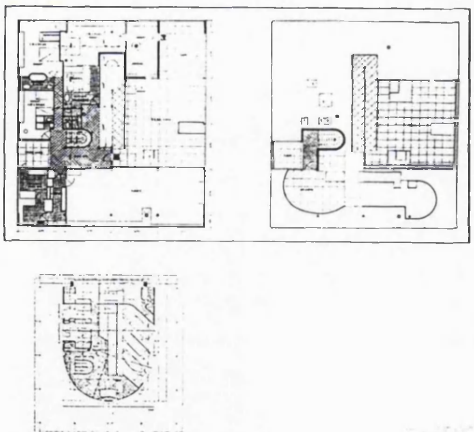
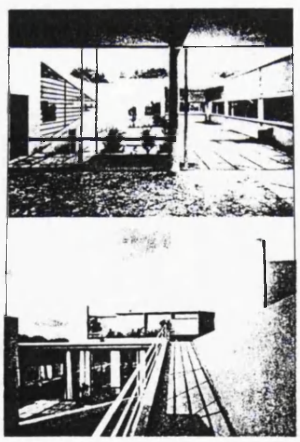
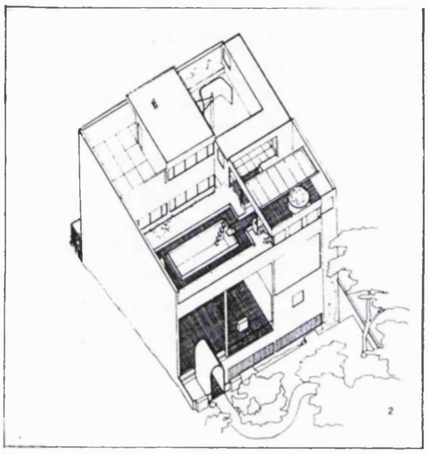
36 37







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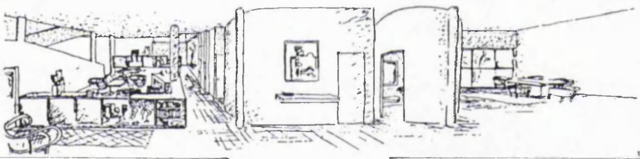

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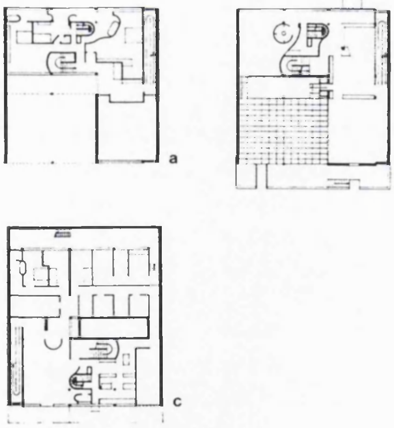


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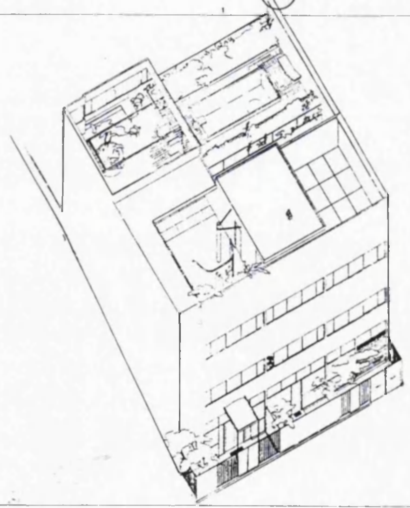

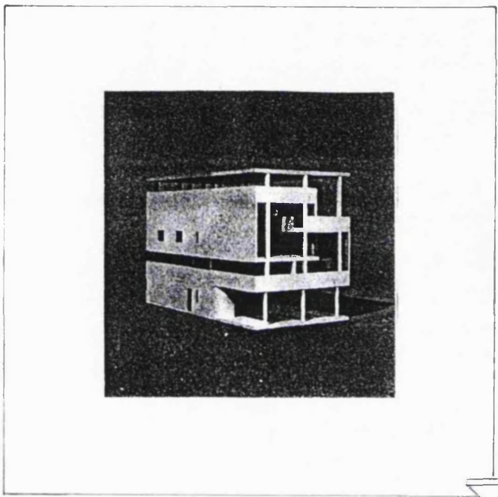

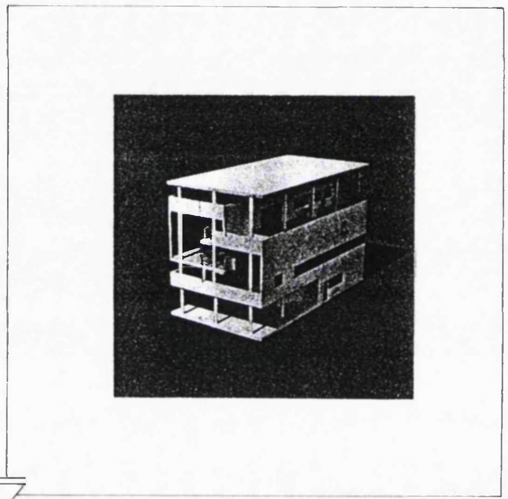

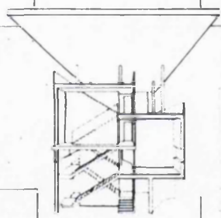

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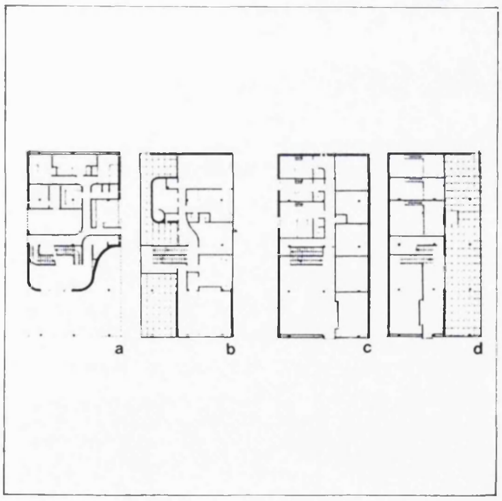


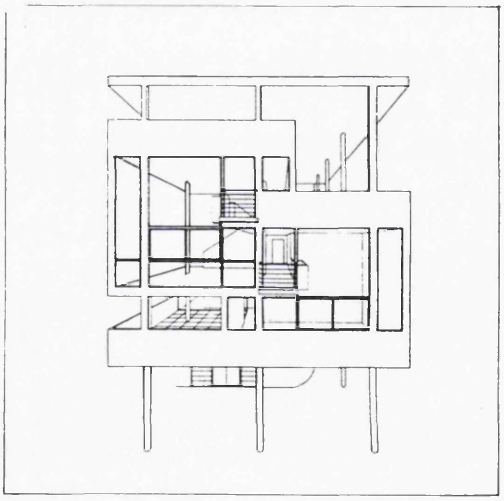

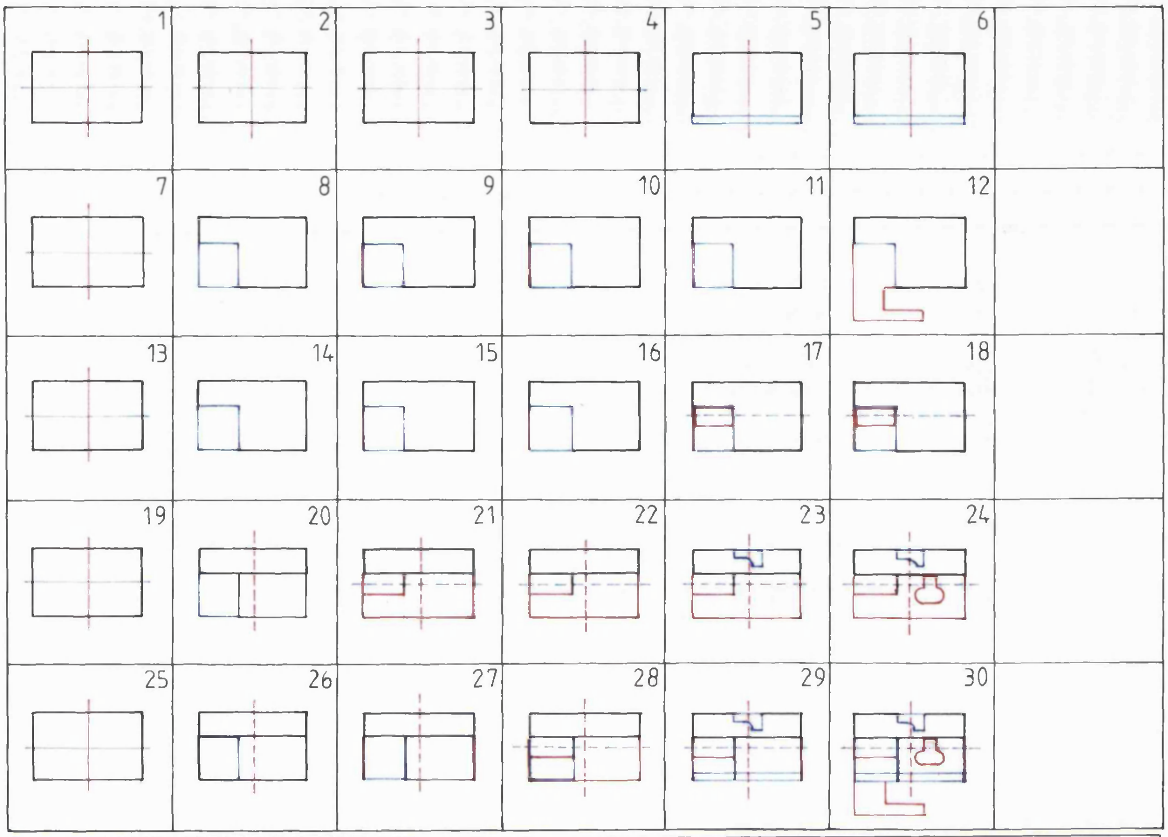


Table **LH1 3.2**
**Shape Geometrical Properties**

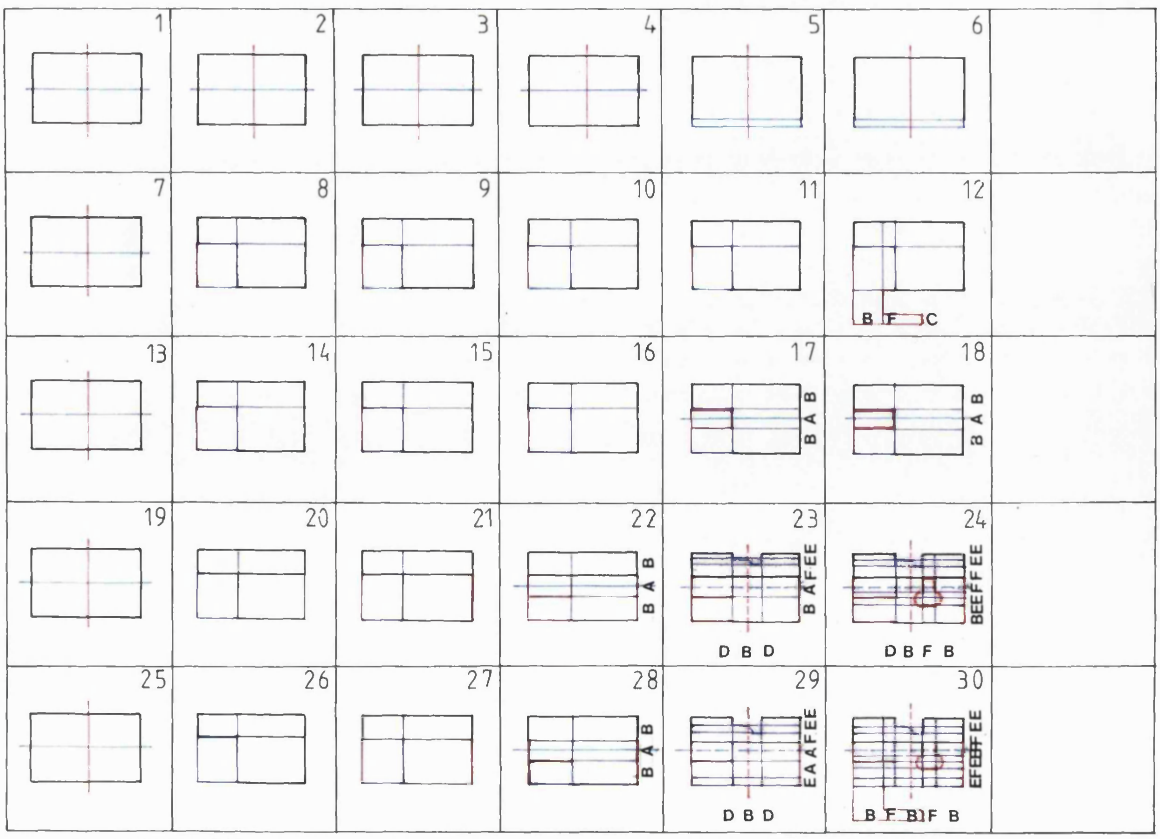


Table **LH1 3.3**
**Grid Geometrical Properties**

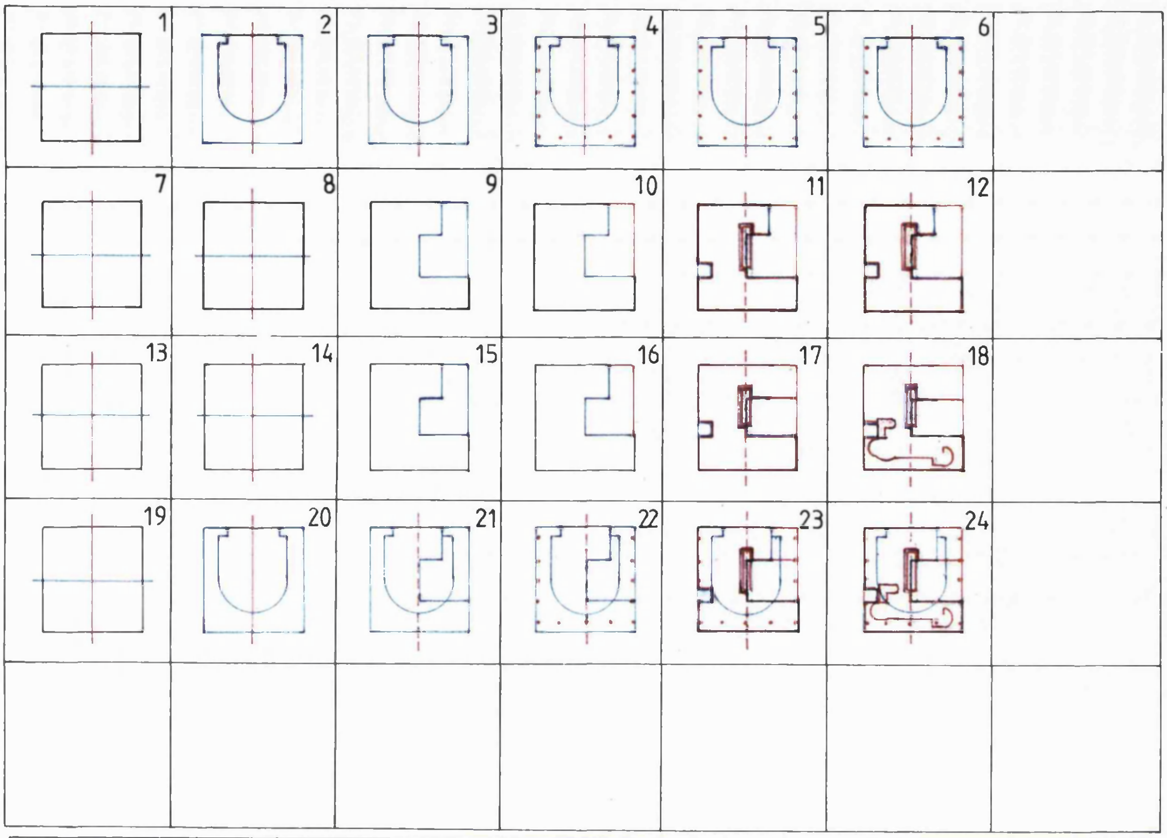


Table **LH2 3.2**
**Shape Geometrical Properties**

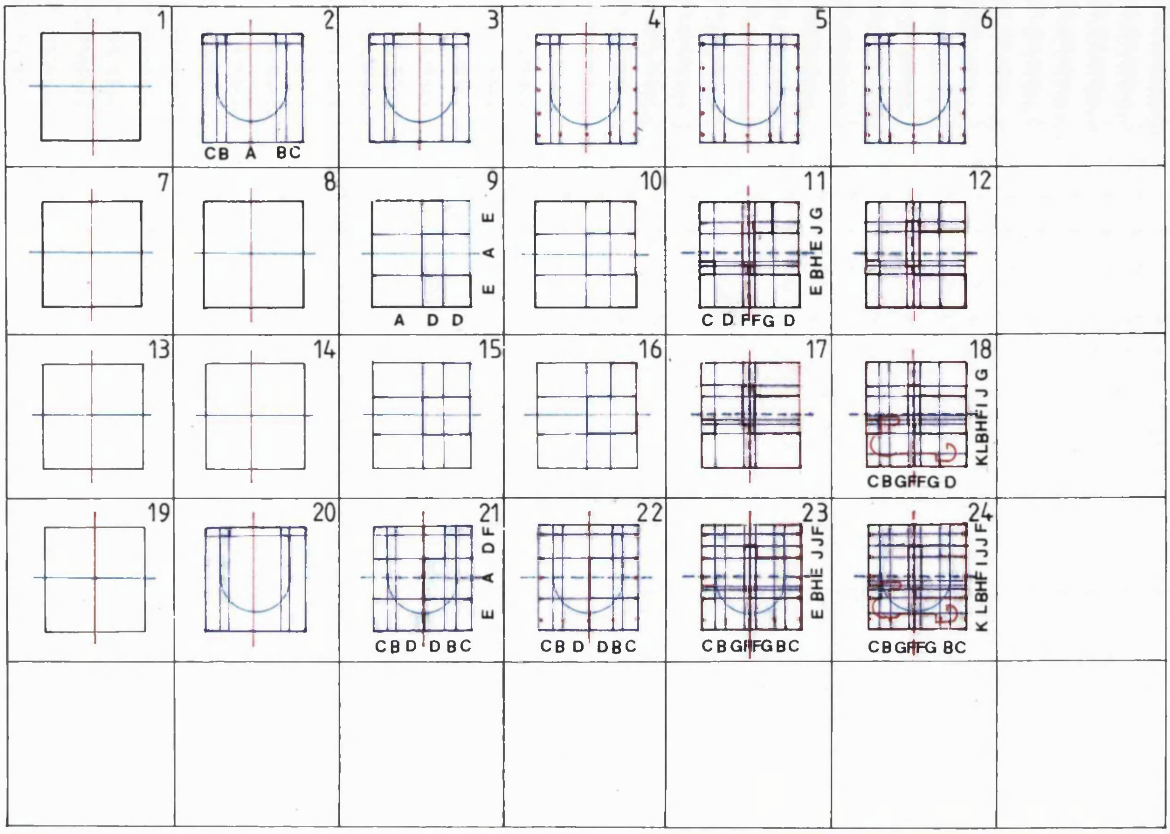


Table **LH1 3.3**
**Grid Geometrical Properties**

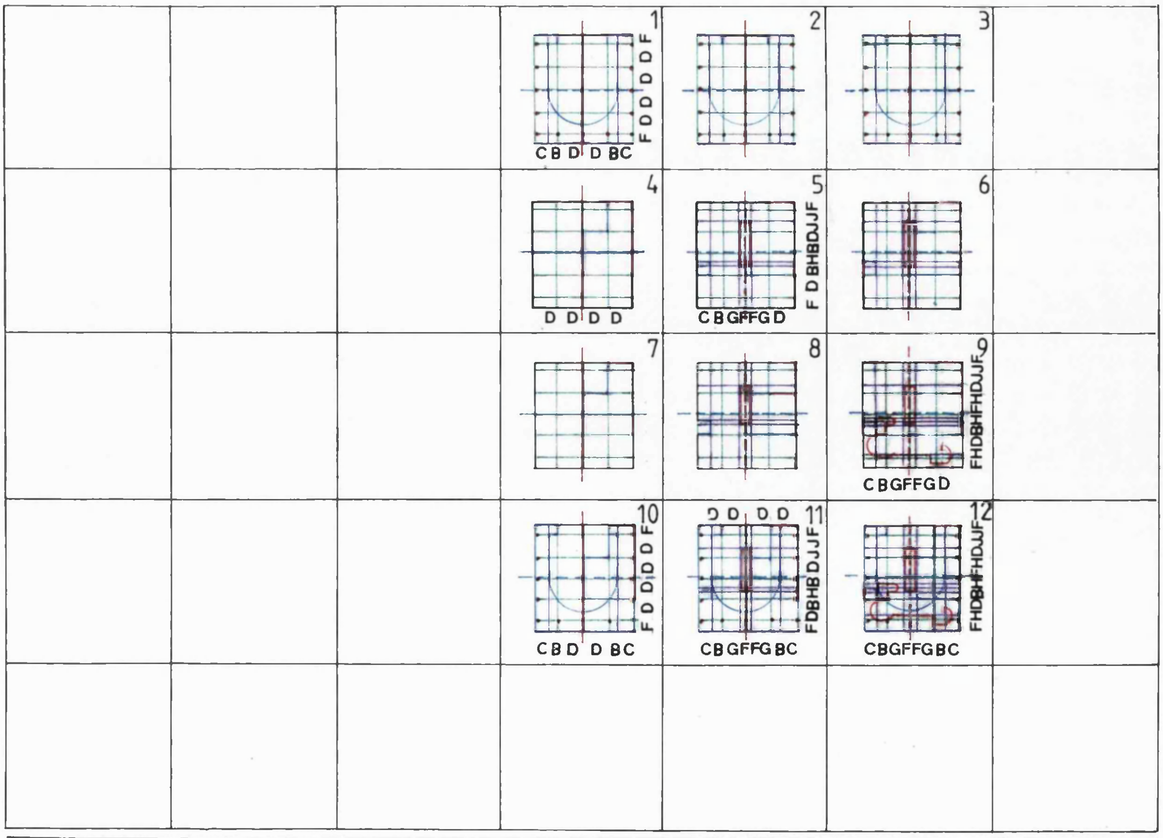


Table **LH2 3.4**
**Structural Grid Geometrical Properties**

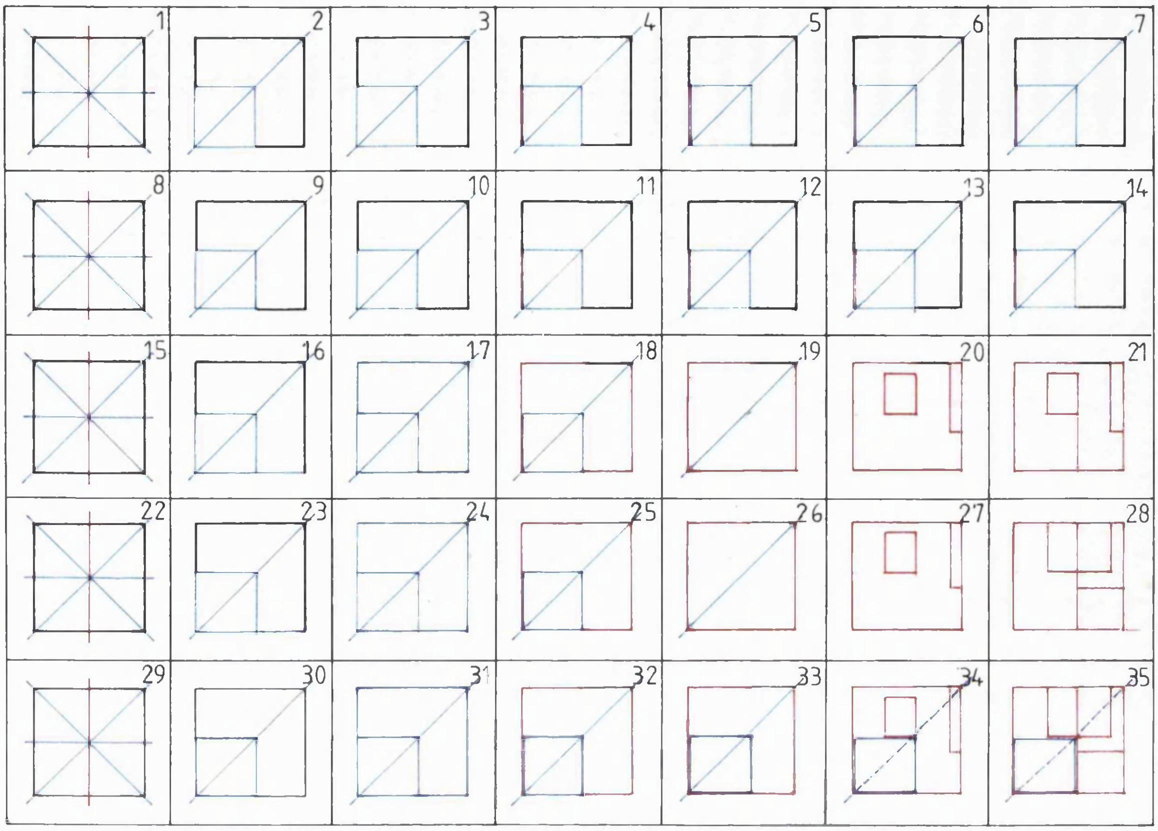


Table **LH3 3.2**
**Shape Geometrical Properties**

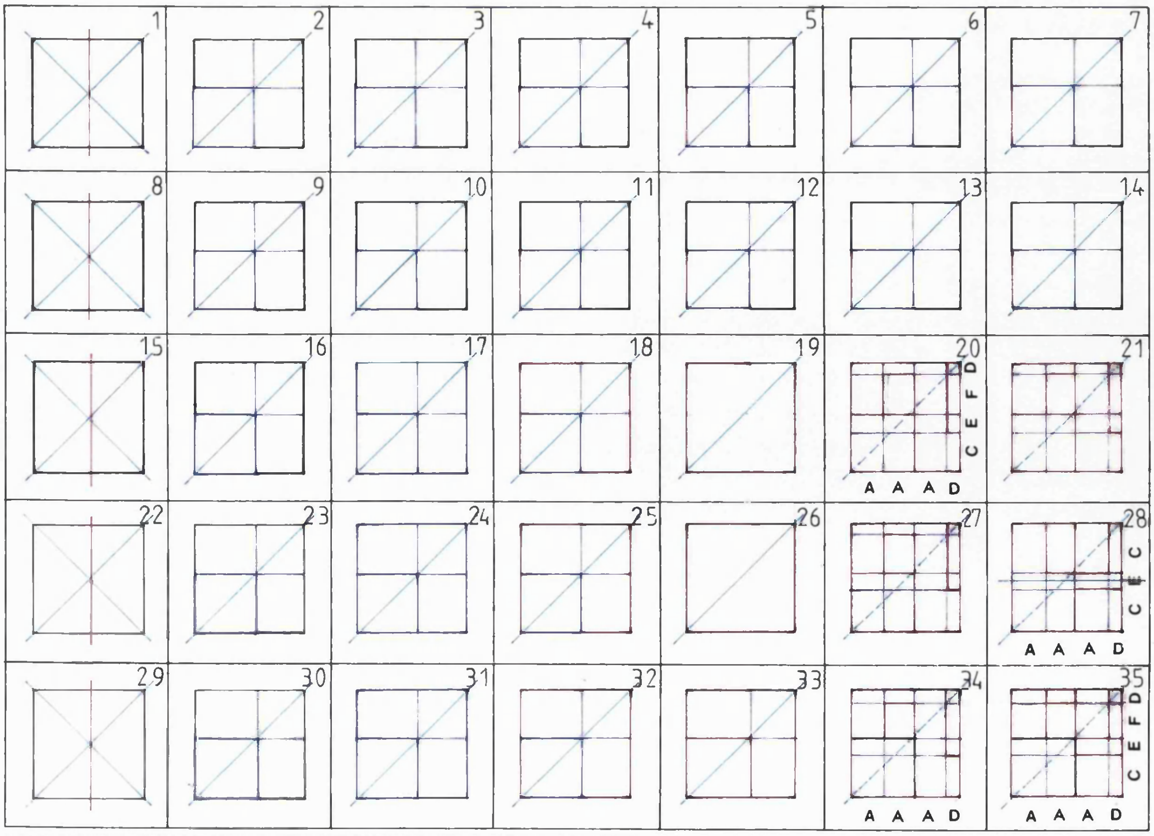


Table **LH3 3.3**
**Grid Geometrical Properties**

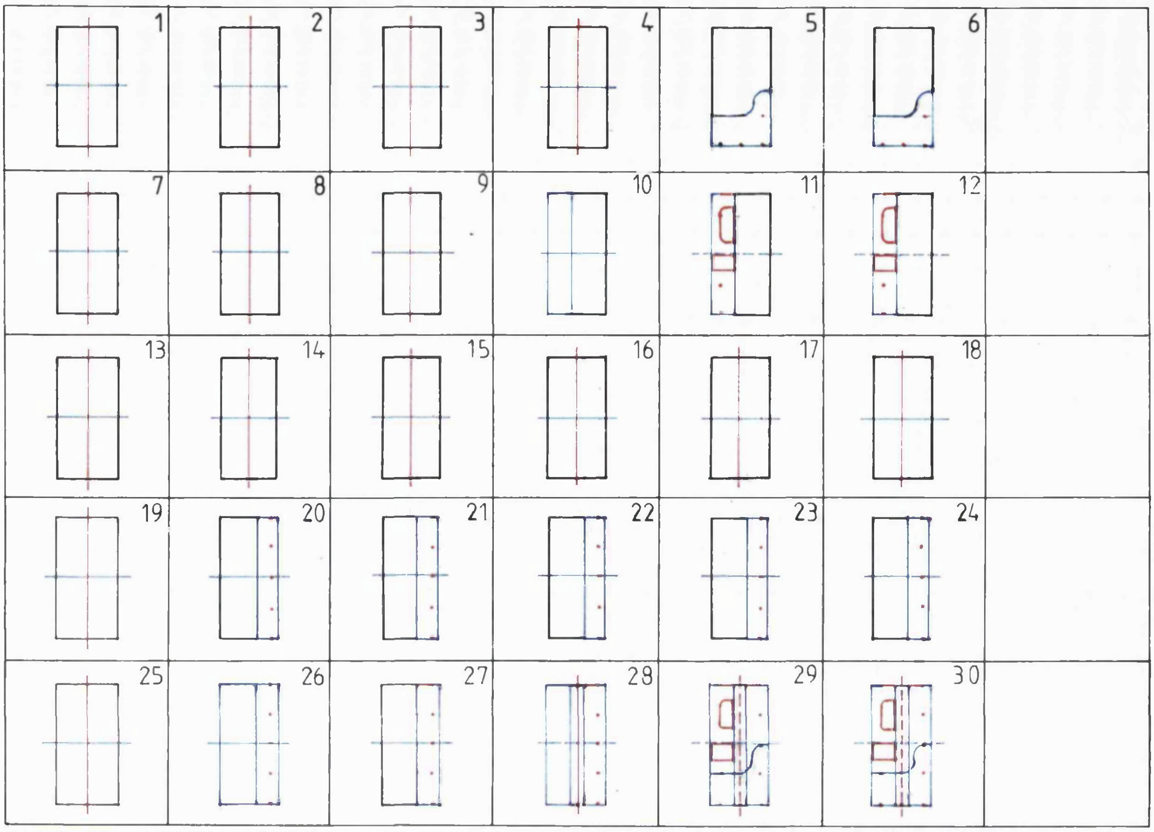


Table **LH4 3.2**
**Shape Geometrical Properties**

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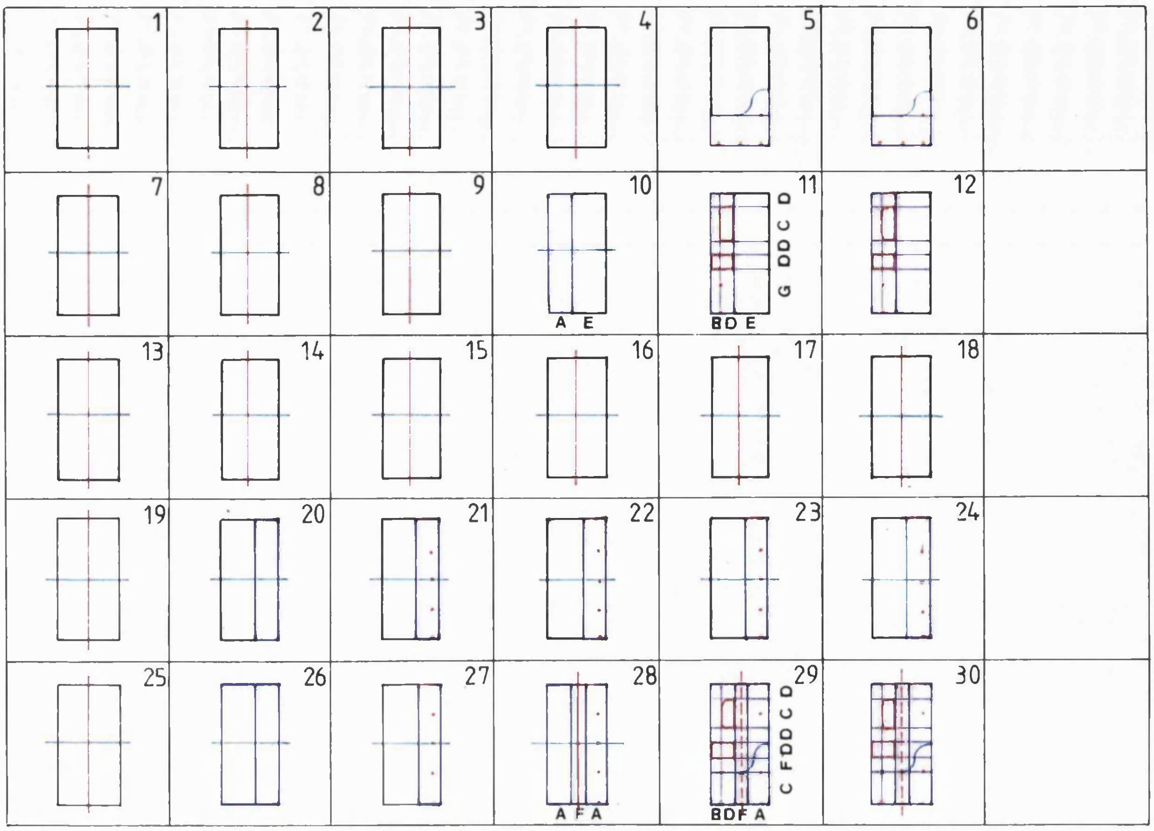



Table **LH4 3.3**
**Grid Geometrical Properties**

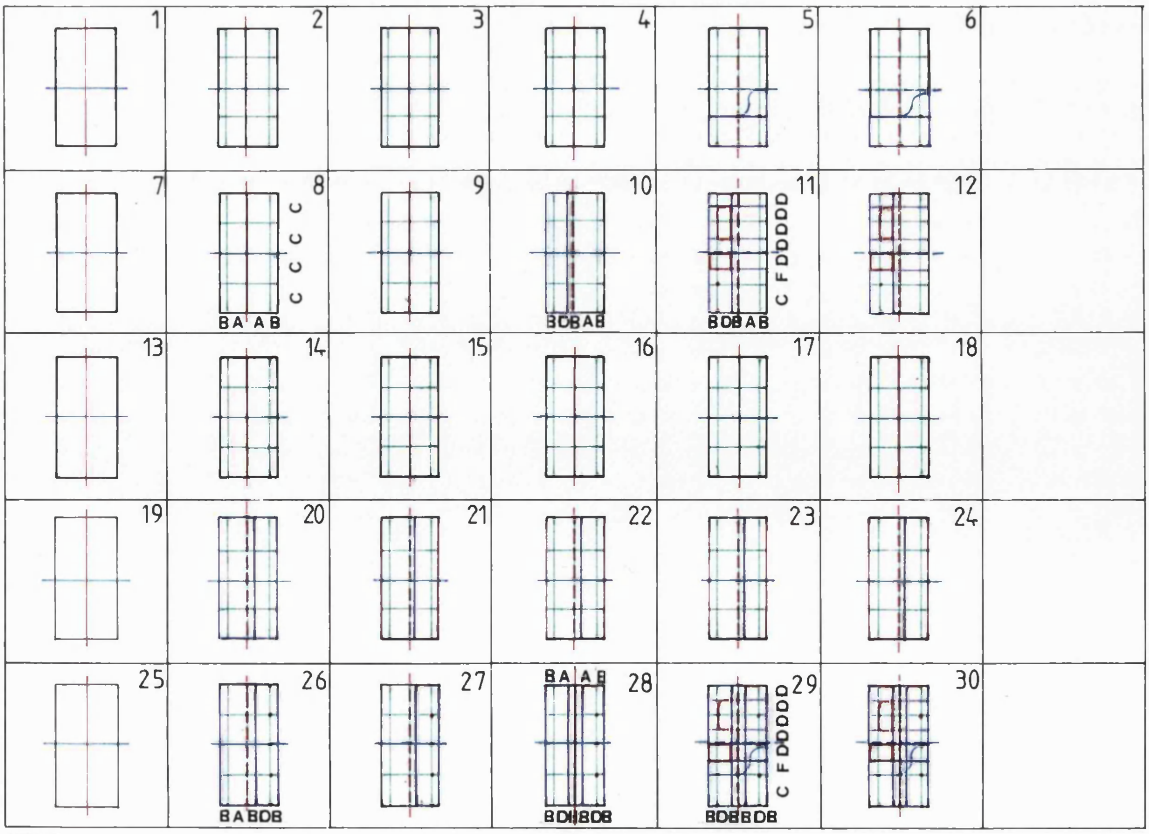
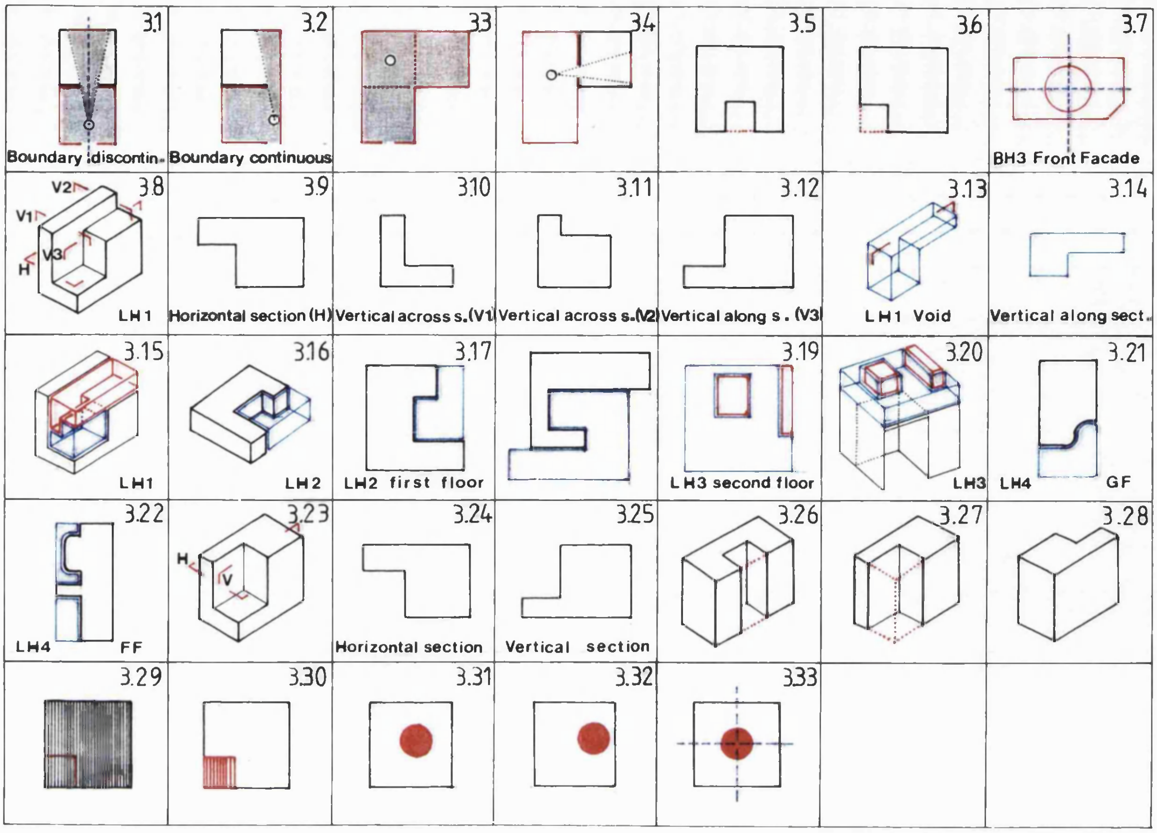



Table **LH4 3.4**
**Structural Grid Geometrical Properties**


3.1
3.2
3.3
3.4
3.5
3.6
3.7
Boundary discontin.
Boundary continuous
BH3 Front Facade
3.8
3.9
3.10
3.11
3.12
3.13
3.14
V2
V1
V3
H
LH1
Horizontal section (H)
Vertical across s.(V1
Vertical across s.(V2)
Vertical along s. (V3
LH1 Void
Vertical along sect.
3.15
3.16
3.17
3.19
3.20
3.21
LH1
LH2
LH2 first floor
LH3 second floor
LH3
LH4
GF
3.22
3.23
3.24
3.25
3.26
3.27
3.28
LH4
FF
H
V
Horizontal section
Vertical section
3.29
3.30
3.31
3.32
3.33

T3.1

- **COMPARISON BETWEEN BOTTA AND LE CORBUSIER**

- **THE PATTERNS OF THE TRANSFORMATION PROCESS**

At the beginning of this chapter a first observation of the eight houses pointed out that both architects use simple geometrical volumes. It also suggested that these volumes are excavated to define open spaces that are enclosed within the perimeter of the volumes. Analysis seems to reconfirm what the initial observations suggested by identifying that:

- Both architects use a prime geometric solid as the simplest geometrical concept describing their houses. This solid is transformed by common operations, i.e. subtraction, addition and planar extension.
- They both start transformation with the subtraction of a volumetric component. At the following stages they continue by excavating the house further and by subdividing the open space into subspaces. Finally, at the last stages they complete articulation by adding volumetric elements at the top of the buildings.

Thus, analysis showed that both Botta and Le Corbusier establish a consistent pattern of transformation. It also suggested that they create an association between particular stages, particular operations, particular types of shapes and particular ways in which these shapes are combined. Thus, they both seem to follow a certain strategy in the ways they transform and shape their design elements.

However, although they use the same operations to sculpture a simple geometrical solid and in spite of certain strategies, they approach transformation in fundamentally different ways.

Analysis identified that Botta preserves the properties of the first stage creating volumes that establish always a connection with the initial solid. On the other hand, Le Corbusier does not continuously preserve these properties. He distinguishes between stages in which he preserves and stages in which he suspends them.

Analysis points out that these two approaches to transformation are based on fundamental differences regarding the order of operations, the shapes the two architects use and the ways they combine these shapes.

- **Operations and their order of occurrence**

In Botta subtraction takes place during the first five stages. Then it is followed by planar extension and volumetric addition, (TB - S AE, p. 162). In Le Corbusier there is an alternating application and suspension of operations in a way that subtraction, extension and addition alternate along the analytic sequences, (TL - SAE, p. 184).

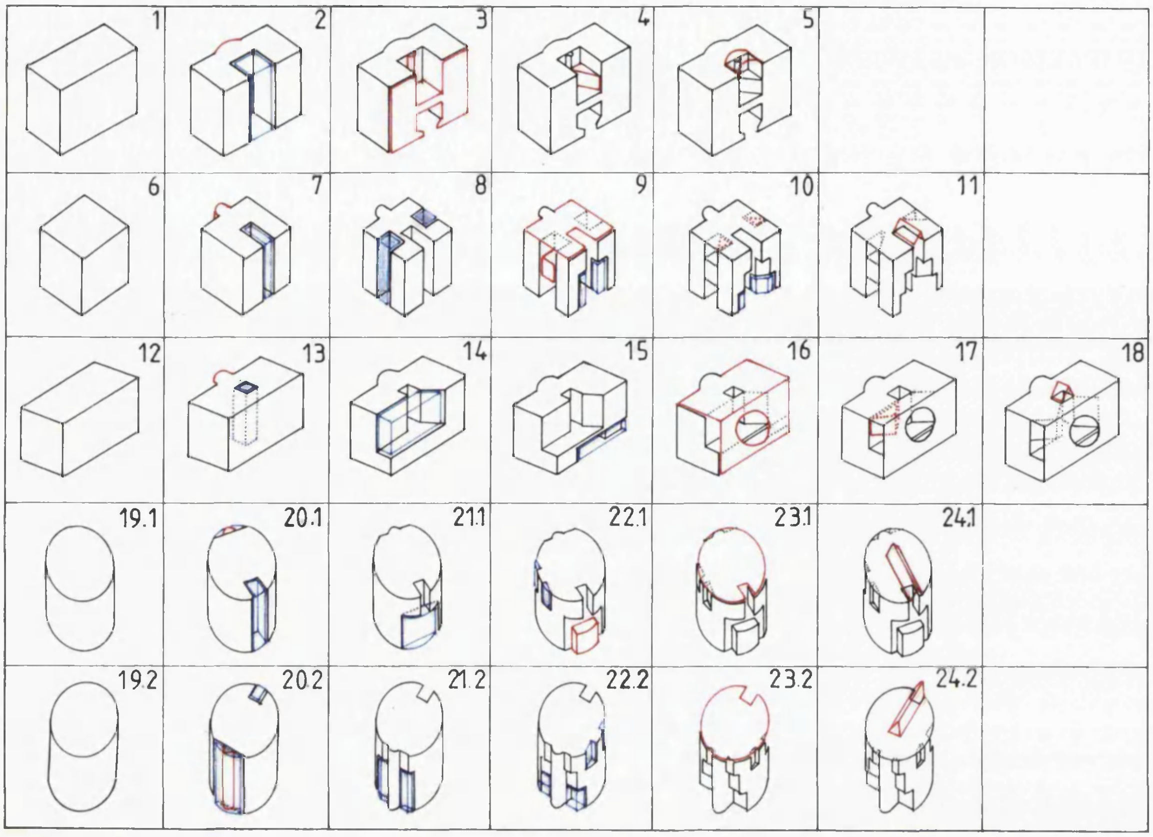



Table **B 3.1**

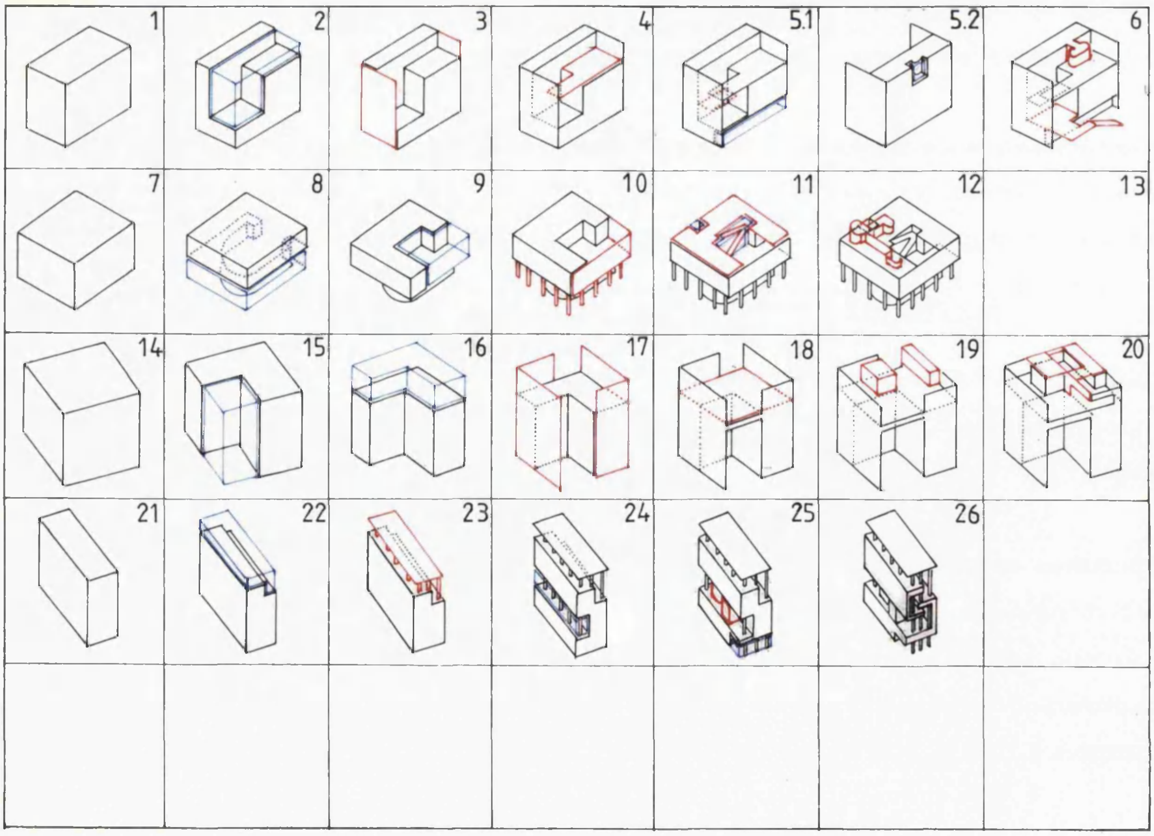



Table **L 3.1**

## THE RELATIONAL LOGIC OF TRANSFORMATIONS

- **The types of shapes**

Although both architects start transformation by subtraction, the shape of the component they subtract is different. Botta always subtracts a rectangular volume, (TB 3.1, fig. 2, 7, 13, 20.1, 20.2). Le Corbusier is not consistent regarding the shape of the subtracted component. In two cases he subtracts a volumetric L, (TL 3.1, fig. 2, 22), whereas in the others he subtracts a curvilinear volume and a volumetric rectangle, (TL 3.1, fig. 8, 15).

The two architects combine their shapes in different ways. Botta hollows out his block always at the centre. The resulting element is a volumetric U. He is, thus, consistent regarding the shape of the subtracted component, the position of the void in the block and the shape of the resulting solid.

On the other hand, Le Corbusier is not characterised by such consistency. The shape of the removed component and its position varies from one house to the other. He subtracts a volumetric rectangle along the diagonal of the block, (TL 3.1, fig. 15), he removes a volumetric L cutting along the length of the block, (TL 3.1, fig. 2), he cuts off a curvilinear U slicing along the periphery of the block, (TL 3.1, fig. 8), and he removes a volumetric L cutting the block horizontally from one end to the other in two directions, (TL 3.1, fig 22). The different shapes he uses and the different locations of the removed component create a different solid in each case.

Further, Botta creates a shaft that always opens towards the front. On the contrary, Le Corbusier creates voids that open at least towards three sides. Thus, *Botta has a fixed repertory of particular shapes and combinatorial possibilities, while Le Corbusier is more flexible and provides with a larger vocabulary of shapes and permutations*.

However, analysis suggested that regardless of the differences in their physical appearance the resulting solids of Le Corbusier are all volumetric Ls either in one, or three directions. Thus, there might be no recurrent use of a specific shape but there is a recurrent use of a 'type' of shape. Besides, although there is not a recurrent combination there is a recurrent 'type' of combination requiring the volume to open towards more than one sides.

Thus, Botta puts emphasis on the depiction of certain shapes and certain combinatorial possibilities. On the contrary, Le Corbusier differentiates the physical, figurative appearances of his elements from one another and from one house to the other and varies the locations of the subtracted components. He, thus, puts emphasis on the impossibility to isolate shapes and to comprehend them by their classification into a clear and identifiable category. This seems to explain the reason for which the houses of Botta look similar to each other, whereas the villas of Le Corbusier present with apparent diversities that make one completely different from the other.

- **RULES OF COMBINATIONS**

- **PHYSICAL PROPERTIES**

- **The volumetric U in relation to the volumetric L**

Analysis suggested that the transformation of the block to a volumetric U preserves the physical properties of the initial solid, whereas the transformation to a volumetric L suspends these properties. The designer achieves design products by a process that manipulates and re - orders morphological systems leading towards the finished product, the building itself. At each stage he looks at these systems deciding where to go next. There is an infinite range of possibilities determining the shape and properties of the new element depending on the operations that manipulate the first one. The designer can each time achieve new shapes that can either keep the initial shape unaltered or they can destroy any connection with it.

If the properties of the initial element appear in the second one then certain limitations are introduced to the range of possible solutions. From all the potential derivations, the designer chooses only those that are realisations of the rules of the first element. Thus, the development of the new shape is not released from restrictions. It is controlled by the rules and the properties of the first stage.

In the transformation of the block to a volumetric U the preservation of the physical properties of the block acts as a restriction to the possible directions the articulation of its shape and properties can take. On the other hand, in the transformation to a volumetric L the restrictions limit themselves to the preservation of fewer properties.

Thus, Botta imposes the physical properties of the initial solid on the volume of the second stage. Le Corbusier puts fewer restrictions to the directions the new volumes take. In Botta the rules governing the transformation of the initial solid come from the solid itself, while in Le Corbusier the control the initial state exercises over the transformation is weaker.

Therefore, the preservation/suspension opposition can be explained and clarified by saying that in the first case the properties of the block direct and restrict the process of its transformation, whereas in the second they play no such restrictive role.

- **The volumetric U and the volumetric L in relation to intelligibility**

Looking at the ways these two objects relate to the block brings about the problem of the role the block plays in the ways they become intelligible.

Both volumes can recreate the block. The former registers back to the initial solid by the extension of two surfaces, whereas the latter by the extension of three surfaces, (fig. 3.26, 3.27, p. 203). Thus, both the volumetric U and the volumetric L incorporate and reveal the process of their making by a redevelopment of the initial state. However, although both volumes refer to their initial condition the former builds up this reference by fewer operations than the latter.

The ability of a configuration to refer to a previous condition means that it incorporates two possible interpretations, or two possible readings. Thus, both the volumetric U and the volumetric L are read as the block and themselves. However, least effort and economy of operations leading to a description determine the degree to which a configuration can easily and directly provide with a particular reading. In this respect the volumetric U seems to be closer to the initial state than the volumetric L.

Besides, the volumetric U retains explicit physical definition of the defining elements of the block, whereas the volumetric L refers to the block by a virtual extension of its surfaces to define the missing elements. In the former there is a physical presence of the block, whereas in the latter there is no such presence. In the former the block is *actually seen,* while in the latter it is *inferred* rather than seen.

The examination of how these volumes become intelligible concerns so far with one particular way by which they become experienced. This is by looking at their three dimensional representations on a flat surface. If real experience is taken also into account then analysis has to consider the ways these volumes are seen as actual physical objects by an observer who moves and sees them from different view points.

In reality the information the observer receives from all the sides of the volumetric U is similar apart from the information received from the frontal view point. In the volumetric L each surface is different from the other. Thus, it looks different each time the viewer changes his point of view, (fig 3.27, 3.28, p. 203).

In the volumetric U information about the volume as a whole is based on fewer observations. In the volumetric L it requires the observer to move around the object and try all different positions. It seems, thus, that the more information an object transmits from limited points of view the more it is understood at a limited amount of time. The more it is understood within a limited time the closer the ways it is seen in reality is to the ways it is seen in drawings, i.e. at a single glance. The more information is distributed to different view points the more direct awareness occurring in drawings is replaced by a sequential awareness of the object.

The argument put forward is that the ways an object is transformed influences the ways it becomes intelligible. The preservation of its physical properties leads to its immediate recognition. On the other hand, the suspension of these properties on the level of representation requires the mechanisms that reconstruct the object, the extension of its surfaces, whereas on the level of concrete experience it requires the combinations of these mechanisms with movement.

- **The following stages - Physical presence of the block**

Analysis shows that in Botta the preservation of the physical definition of the block restricts the transformation process throughout the analytic stages. The voids are articulated by subtraction or addition in ways that the vertexes and the edges of the largest volumetric component are not affected. Planar extension is an additional device the architect employs to increase the physical demarcation of the initial solid. Regardless of any complexity achieved by the articulation of the volume, the reading of the block is constantly sustained.

Le Corbusier in some stages reduces the physical definition of the block further. In these cases the physical properties of the block do not control the rules of volumetric subtraction. In other stages he uses planar extension to restore the physical definition of the initial solid. Thus, in Botta the rules preserving the physical identity of the block continuously direct every operation, whereas in Le Corbusier they are suspended at one stage and re-introduced at another. His design logic is based on a back and forth process that first releases the volume towards one direction and then controls it and brings it back to the initial condition.

The extended surfaces restore some of the physical elements of the block to ease intelligibility of the block. However, full physical definition of the destroyed vertexes is not achieved. As opposed to Botta who constantly offers *explicit physical definition of the block,* Le Corbusier offers *implicit physical definition. One looking at Le Corbusier's buildings is 'aware' of the block. Looking at Botta's houses he 'sees' the block. In the former the block is deciphered, in the latter it is actually there.*

Further, in Le Corbusier the absence of full physical definition of a vertex makes the extended surfaces to register as planes. Thus, at these stages *the block and the other volumetric components provide with both volumetric and planar readings.* The volumes refer back to their origin but this is achieved at the dispense of their volumetric clarity.

In Botta the transformations at the middle stages change the articulation of the voids without aiding to the physical definition of the block. In Le Corbusier these transformations change the physical appearance of the secondary solids and voids aiming at the restoration of the block. Thus, in Botta the application of the rules of the initial solid to the secondary components creates hierarchical distinctions among the volumetric concepts in a way that changes occurring in the latter do not affect the former. In Le Corbusier lack of hierarchy creates a mutual dependence between the block and the rest of the elements in a way that changes of the one affect the other. The block and the secondary volumes enter into complementary relationships. The decomposition of the former defines the latter. Besides, the redefinition of the former requires the decomposition of the latter.

Thus, in Le Corbusier the planes define the block, the secondary solids and the voids providing readings of all these elements. In Botta the surfaces that define the block are different from the surfaces that define the voids. Elements register into perception clearly based on a taxonomy that differentiates among their defining elements and on an hierarchy that establishes the control of the initial solid over the rest of the components.

- **PHYSICAL PROPERTIES AND INTELLIGIBILITY**

Clear distinctions and hierarchical relations give predominance to the block. Mutual connection of parts makes the elements to register alternatively either with one reading or with the other. The lack of hierarchical order creates shifting emphasis from the one to the other. A contour defining more than one shapes has this property. It registers towards one direction where one shape is perceived as closed. Its property to participate to the definition of another shape creates a second reading. Each reading is achieved at the dispense of the other because it requires the defining elements of the other shape to achieve its description.

To demonstrate this point better the examples of figures 3.5, 3.6, (p. 203) are used. The volumetric U in figure 3.5 can register also as a large and small rectangle that are both completed by the extension of a missing surface. The two shapes share no boundaries apart from this surface. The boundaries of the volumetric L, (fig. 3.6), together with the extended surfaces define a large volumetric rectangle and a smaller one sharing the left and the front surfaces.

In the first figure the two rectangles are read simultaneously based on the clear separation among their defining elements. The grasping of each shape is not disturbed by the other because different surfaces correspond to each of them. In the second figure the grouping of the boundaries to define one of the two rectangles suspends the perception of the other and vice versa. This is because each grouping requires the defining elements participating also in the other to achieve its description. Thus, these shapes are perceived at the dispense of each other and attention shifts from the small to the large rectangle.

The property of the same boundary to define two shapes was also introduced by the notion of a continuous boundary in figure 3.2, (p. 203). This property is translated into a mutual definition of two spatial volumes by the internal side of a single boundary. Figure 3.6, (p. 203), shows that this principle can be applied also to the external articulation of volumes by both the internal and the external side of a surface.

This device is extensively used by Le Corbusier in even more complicated arrangements. Figure 9, in TLH2 3.2, (p. 198), shows an horizontal section through the first floor of LH2 at stage four. The solid and the void L interlock and interpenetrate joined together by a mutual definition of boundaries. Each

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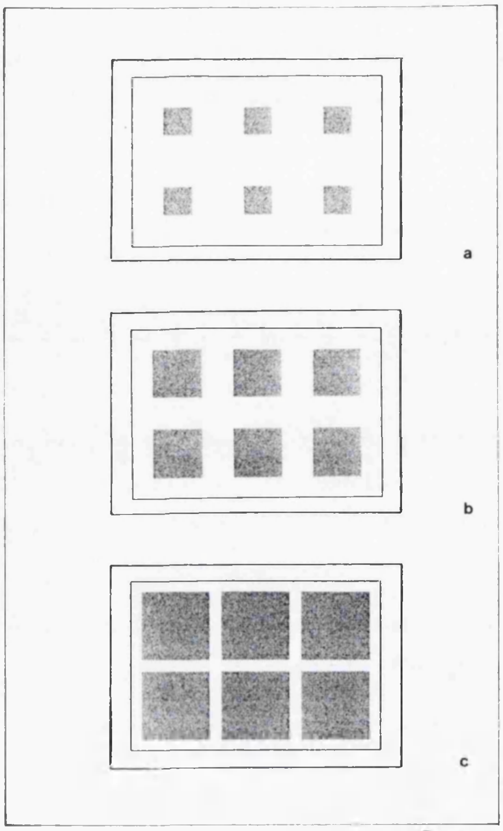


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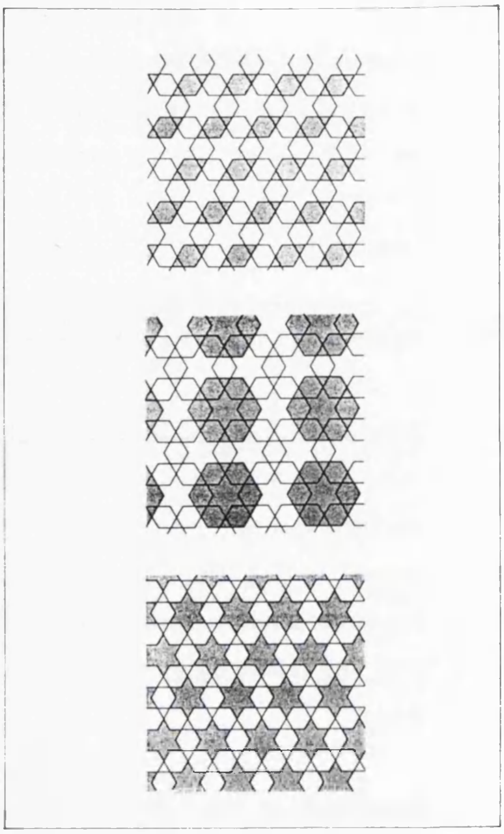

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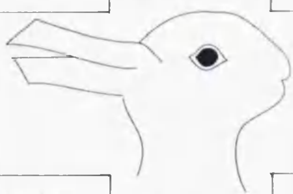
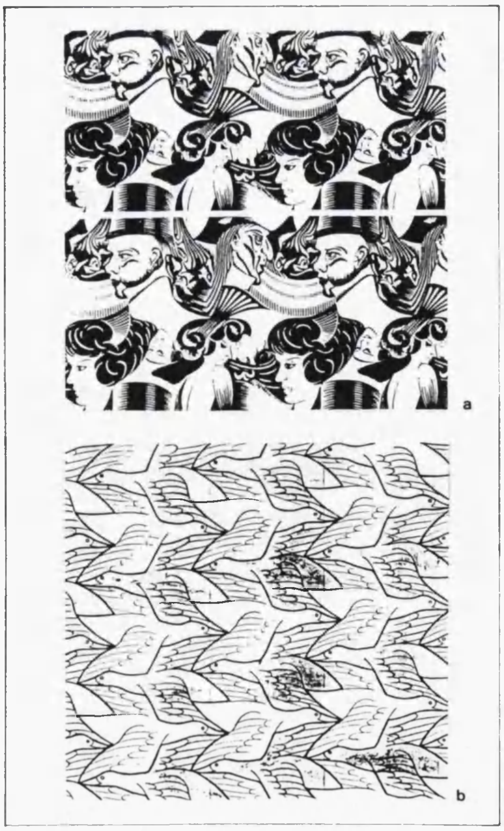


(50)

The rabbit-duck figure

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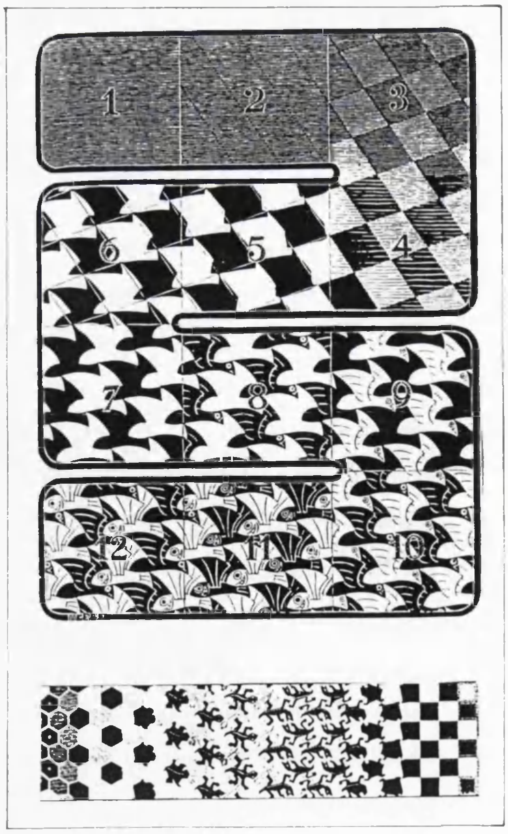


(49)

time attention is attracted by one of the shapes the other fades into the background. There are moments that one shape becomes the figure and the other the ground and moments that the situation is reversed. The same phenomenon takes place in figure 24 in TLH1 3.2, (p. 197), presenting an horizontal section through the third floor of LH1, in fig. 27 in TLH3 3.2, (p. 200), showing a section through LH3 and in figure 11 in TLH4 3.2, (p. 201), showing an horizontal section through LH4.

The principles of figure and ground and of grouping elements into recognisable figures - like lines, shapes and higher order figures like clusters of shapes - are studied extensively by Gestalt psychologists who defined "Gestalt laws" that govern figure perception. According to these laws a figure is something that absorbs attention differentiating itself against a background, and gestalt laws describe how this is done.

The impact of the properties of figures and of the properties of their groupings on perception is often stressed to demonstrate that perception changes when these properties change also. Thus, R. Arnheim has noted that in a facade small windows appear as figures against the ground of a wall[35], (illustration 3.46). If the ratio of the opening to the wall surface is changed the facade reads as an alternation of solids and voids none of which is unambiguously figure or ground. Whereas at the beginning the background is seen as a surface against which the small rectangles are placed, (illustration 3.46a), at the end figure and ground have no clear distinctions, (illustration 3.46c). What has become of the surface is a grid of narrow vertical and horizontal strips that oscillates from the foreground to the background.

It seems that this ambiguity is created not only by changes on the proportions of the windows in relation to the facade but also by the property of the boundaries of the small rectangles to define both these shapes and the grid structure[36].

In the previous chapter it was suggested that what creates ambiguous readings is not perception shifting from the one object to the other but a complex system of operations, elements and rules that hold them together. Thus, a number of readings are included in a configuration specifying a number of possible transformations. If perception in figure 3.6, (p. 203), oscillates between one shape and the other it is because subtraction and extension are both possible readings pointing at two different directions: the planar L and the two rectangles generated by the extended surfaces.

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35 W. Mitchell, 'The Logic of Architecture, Design, Computation, Cognision', The MIT Press, 1990, p. 4.

36 The grid structure is implicitly present in all three examples of the facade. However, in the third example it becomes explicit by the increase of the areas of the grid lines that are physically defined by the elements of the rectangles. This leads to a hypothesis that is useful for the analysis of the geometrical grids and for the future analysis of the interior space. This hypothesis suggests that the more grid lines are defined by surfaces the more they are raised to the level of the observable orders.

Chapter one and two suggested that the problem with Gestalt laws lies not on the ways they define the perceived configurations but on their theoretical explanations regarding how perception occurs. Shifting from a pattern to its perception these laws dissociate structural parameters from the ways they become intelligible. Thus, the observations of the Gestalt psychologists about ambiguous readings of figure and ground are considered as having a certain validity. As such they are used by this analysis to support its arguments.

The ambiguous reading of figure and ground is used in decorative art as well as in other forms of art[37]. It is known by the Islamic designers who achieve grid patterns that create a variety of figures to pick out from them, (illustration 3.47, p. 210). It is also used by the Dutch artist M. C. Escher who has been extensively engaged on the creation of figure ground reversals creating networks of interpenetrating images of animals, (illustrations 3.48, 3.49, p. 210).

Analysis of Escher by Bruno Ernst examines how 'metamorphosis' is planned and described by the artist[38], (illustration, 3.49, p. 210). His analysis shows that a transformation of an abstract regular grid system to the specific naturalistic bird/fish pattern is based on gradual changes occurring to the black and white rectangles at the top right side of the composition and sustained by the underlying grid structure linking his shapes into a dense network. The mechanism by which the artist achieves the metamorphosis as well as the figure ground reversal is founded on the transformation of regular convex shapes to irregular concave shapes that interlock with each other.

'The rectilinear nature of the black and white boundaries is slowly changing, for the boundary lines curve and bend in such a way that an outward bulge on the one side is balanced with an equal - sized inward bulge in the opposite side'[39].

Le Corbusier seems also engaged with the construction of interlocking concave shapes as figure 9 in TLH1 3.2, (p. 197), figure 24 in TLH2 3.2, (p. 198), figure 27 in TLH3 3.2, (p. 200), fig 11 in TLH4 3.2, (p. 201), show. Two and three dimensional representations of his buildings engage the observer into a constant inspection where one interpretation follows another and none of them is separate from the others. The interlocking volumes seem to alternate in the observer's perception in a way that is analogous to the figure ground interchange exhibited by Escher's patterns. On the other hand looking at Botta's buildings the observer always sees and understands them as singular volumes that are clearly sculptured to accommodate individual voids.

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37 Gombrich defines this property of mutual definition of shapes by a common boundary as 'counterchange' occurring in decorative patterns coming from all parts of the world. E. H. Gombrich, 'The Sense of Order, A Study in the Psychology of decorative Art', Phaidon Press Limited, 1984, p. 89.

38 Bruno Ernst, 'The Magic Mirror of M. C. Escher', Tarquin Publications, 1985, p. 37.

39 Ibid., p. 37.

Alternating readings are discussed by psychologist and philosophers who use the duck - rabbit drawing, (illustration 3.50, p. 210), to illustrate the interaction of shape, recognition and order. The argument that is put forward by E. H. Gombrich is that:

'To see a shape as a camel means to look out for the features of the creature, such as the head and the legs. The parts which make up the motif will automatically cohere, while the residue will turn into mere 'background' or 'filling', until, that is, somebody points out to us that these shapes we regarded as meaningless also have their representational function'[40].

In 'Art and Illusion' he suggests that reading of the drawing as a rabbit or as a duck alternate but there is no way they can occur simultaneously[41]. Arnheim discusses also the same phenomenon suggesting that this drawing allows for two different readings arising out of a single shape[42]. The simultaneous definition of shapes by the same surfaces creates an effect that can be compared to the duck - rabbit phenomenon. *It is the property of the same contour to carry information about two different structural concepts that can sustain both meanings.*

As far as concrete perception of the buildings is concerned, in Botta the viewer can try specific locations to achieve a global understanding. To his perception regardless of differences between the front and the rest of the sides, the large scale volume is always irreplaceable as the dominant element structuring his understanding of the building. Moreover, the similar treatment of corresponding faces reduces the number of positions he can try in order to receive global information about the building.

Le Corbusier's villas present with a different face from each side. Thus, Villa Stein from the front refers to the scale of the block as a whole, (illustration 3.30, p. 175 ). From the sides the block is still present but the large openings revealing the terraces behind the planes question its volumetric character inviting the visitor to speculate and test his hypothesis by moving around to see all aspects, (illustration 3.30, p. 175). From the garden front a different configuration of the volume challenges the first readings, (illustration 3.31, p. 175). The block is dissolved to sub volumes and an interplay of volumes, planes and surfaces achieves simultaneous groupings of the same elements into complementary concepts[43].

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40 E. H. Gombrich, Ibid., p. 143.

41 E. H. Gombrich, 'Art and Illusion, A Study in the Psychology of Pictorial Representation', 1977, p. 5.

42 Rudolf Arnheim,'Art and Visual Perception, A Psychology of the Creative Eye', University of California Press, 1974, p. 95.

43 It is only Villa Savoie that can give an overall reading from few positions. The terrace planes enclosing the first floor open space provide with readings that look similar from different view points. However, a second reading questions the apparent similarities observed at the beginning. A difference between the four sides becomes evident when the observer realises that behind the unified treatment of the external surfaces with the ribbon windows travelling around the building lies a garden terrace. Besides, analysis pointed out at this house

As Gombrich suggests perception oscillates from one concept to the other and although one is aware of both there is no way he can perceive them at the same time. After a strenuous attempt to organise the information he receives, the visitor realises that he achieves awareness of multiple relations alternating into his perception but never resolving themselves into a single static interpretation.

- **GEOMETRICAL PROPERTIES**

Analysis identified that the two types of transformation process refer not only to the physical properties but also to the geometrical properties of the volume in process. Thus, in Botta the axes of the block restrict systematically the location of elements resulting in symmetrical configurations. In Le Corbusier there are stages in which this restriction is applied and stages in which it is not. The opposition between a preservative and an obliterative type of transformation is expressed in his buildings by an opposition between symmetry and asymmetry.

- **Geometrical properties of the shapes**

The types of shapes the two architects use influence fundamentally the geometrical treatment of their volumes. The prime volumetric solids of Botta are symmetrical with respect to two axes running through their geometrical centres. These elements enter into symmetrical relations with each other with respect to the BF axis.

Analysis also showed that in Botta there is a clear hierarchical distinction between the BF and the LR axis. Thus, whereas the former co-ordinates large scale relationships, the latter controls relations of a local scale. The hierarchy between the two axes is applied in every single horizontal layer ensuring the priority of the BF over the LR axis in the third dimension also.

On the other hand, the asymmetrical volumetric Ls of Le Corbusier disrupt the development of symmetry on each individual level as well as on the level of the building as a whole. However, symmetry is employed at the first stages of the analysis.

Nevertheless, even at these stages it does not become a three dimensional organising principle of the volume as a whole. A contrast is created between overall symmetry (on two dimensions) and asymmetry of individual levels, or between overall symmetry along one axis and symmetry of the floors along another or by asymmetry on the global level and symmetry of the individual floors,. Thus, whereas Botta

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the simplicity of the external articulation is contrasted by the complexities of the internal articulation of the solid and void consituents. This is something analysis of the interior organisation will deal with in following chapter.

subordinates all horizontal levels to a single element, Le Corbusier offers his horizontal layers the possibility to function as independent geometrical systems.

In Botta the axis becomes gradually intensified by a gradual increase of the number of elements that it co-ordinates. In Le Corbusier it is not picked up by any of the secondary elements staying at the level of the simplest volumetric concepts. Thus, in Botta the systematic gathering of geometrical centres along the BF axis achieves an implicit physical definition of this axis. In the latter absence of axial synchronisation of geometrical centres does not highlight the geometrical axes of the initial solid.

It has been suggested that whereas shapes are directly seen and understood as physical entities, their geometrical properties are not actually seen but understood as abstract sets of relations held among their physical elements. Rudolf Arnheim suggests that what a person perceives in the visual pattern of figure. 3.31, (p. 203), 'consists of more than the shapes recorded in the retina'[44]. Perception of the disk and of the square relies on an interplay of properties inherent in their pattern like shape, size, location, colour and the set of geometrical axes passing from their geometrical centres. Arnheim's suggestion is that these are properties of the objects themselves and they are derived by previously acquired knowledge and past experience. Thus, a complete circle is induced from an incomplete drawn circle, a vanishing point in a perspective can be traced by the converging lines even if no actual point of intersection is seen.

This suggestion can demonstrate clearly what he means by saying that there are locations of the disk that look 'too close, possessed by the urge to withdraw from the boundary'[45], (fig. 3.32, p. 203) or 'the disk is most stably settled when its centre coincides with the centre of the square'[46], (fig. 3.33, p. 203), if the basic law of perception of Gestalt psychology is taken also into consideration: 'Any stimulus pattern tends to be seen in such a way that the resulting structure is as simple as the given conditions permit'[47]. It is suggested here that the geometrical axes of both shapes are perceived and that the viewer compares each time the given configuration with the simplest possible relation among these axes. This is achieved when the four axes of both shapes coincide, (fig. 3.33, p. 203). The urge of the circle to move towards a more 'stable' position is, thus, interpreted as the urge of the viewer to test the given structure against the simplest possible structure induced by previous knowledge and conventional experience.

This research proposes a slightly different interpretation of this phenomenon, i.e. the understanding of the displaced axis of the circle by reference to the situation when this axis and the axis of the square coincide. Understanding the displaced circle against a simpler and more regular configuration is about understanding a transformation that breaks the symmetry of the square.

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44 Rudolf Arnheim, Ibid.,p. 15.

45 Ibid., p. 12

46 Ibid.., p. 12.

47 Ibid., p. 53.

When transformation preserves this symmetry, gathering all the elements under the same axis, a single reading is constructed. The less this symmetry is preserved the more axes are introduced, i.e. the more the initial and the secondary states of the transformation pull towards different directions.

In the previous chapter it was suggested that shape symmetry is a structural property operating at the abstract level. The defining elements of the shape bring this property to the representational level. The more shapes are gathered under the same symmetry the more the axis is raised to the representational level, i.e. the more it becomes observable. Thus, it seems that *when geometrical relations are synchronised by a single rule they are raised from the level of abstract properties to the level of the observable properties.*

The co-ordination of geometrical centres in Botta aims at a configuration that synchronising relations of every element with every other element under a single organising axis can be easily grasped. The visual pattern with its inherent properties of shape, position, and geometrical axes registers directly into perception and is comprehended due to a preservation of a single property.

The systematic strengthening of the simplest geometrical volume and of its geometrical properties forms the key concept in the perception of the building drawing attention to itself. Thus, the viewer is constantly reminded of the importance of the block and of its organising strength.

In Le Corbusier a lack of co-ordinated centres creates a configuration that does not rely on symmetry preservation and on the distinction of the simplest geometrical concepts over the rest of the concepts, to be understood. Perception of his houses is not directed through a specific channel in which a single geometrical element plays the dominant role.

However, his twofold approach regarding the properties of the block, results in lack of overall symmetry on the one hand and in local symmetries on the other. The employment of symmetry at the first stages ensures a global form of control that is challenged at the final stages. Thus, he accepts the symmetry of the simple geometrical concepts as playing an important role in the organisation of the building but he limits their control to the first stages of the transformation process creating what C. Rowe has defined as a symbiosis of systems or as 'a tension between the organised and the apparently fortuitous'[48].

The suggestion is that by the preservation/suspension opposition realised as an opposition between symmetry and asymmetry, Le Corbusier provides with a certain degree of geometrical control. This control achieves its strength by operating at the simplest levels of structural concepts of the first stages

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48 C. Rowe, ' The Mathematics of the Ideal Villa and other Essays', The MIT Press, Cambridge, Massachusetts and London, 1982, p. 12.

giving, thus, a background of an intelligible pattern against which the deviations of symmetry are projected.

It seems that the same effect achieved between the circle and the square is created. The viewer focuses on the symmetry of the largest volumetric components that, like the square, enter his perception by virtue of being the highest structural concepts. Their defiance on the level of the specific state of the building challenges the overall pattern in a way that the secondary elements pull themselves from the centre.

Similarly to the circle the position of which is tested against a higher structural concept, the square and its symmetry, the viewer returns from the specific to the abstract state. He moves back to the largest volumetric concepts and tests the locations of the smaller ones against it. Thus, he becomes engaged into a constant back and forth process trying to resolve the complexity of the organisation without achieving a single interpretation around a single organising pattern.

- **Geometrical properties of the grids**

Analysis suggested that Botta preserves the symmetries of the initial solid and the tripartite organisation of the second stage by articulating grids that are symmetrical with respect to the BF axis of the block in every stage. On the other hand, Le Corbusier employs symmetry and tripartition that is not built up systematically and is not applied in every analytic stage. However, the large grid system (consisting of the superimposition of the physical grids of all horizontal sections and the structural grid in LH2 and LH4 and of the superimposition of all physical grids in LH1 and LH3) is symmetrical and tripartite in three of his four houses at the final stage, (LH1, LH2 and LH4).

Thus, Botta creates a constant association between the geometrical properties of the shapes and the geometrical properties of the grids. Le Corbusier creates a dissociation between the two levels of properties substituting symmetries of the shape organisation for less obvious symmetries of the organisation of grids.

Analysis has suggested that symmetry of a configuration seen as an arrangement of shapes registers more directly into perception than symmetry held among the grid lines. Perception seems to be influenced from what is immediately visible. Seeing the outline of shapes one seems to capture their reflective symmetries. Seeing these shapes as generators of a grid system and understanding the geometrical properties of this system is a more difficult task presenting with some intrinsic difficulties inherent first in the nature of the physical objects and second in vision.

In a drawing one has to draw the extensions of surfaces in order to 'see' the underlying network of lines establishing relationships of each element with rest of the elements in the configuration. In reality the recognition of a grid system becomes more difficult. One is not able to see the lines extending behind the walls. Gombrich writes: 'we see objects only from one side, and we have to guess, or imagine what lies behind'[49]. As he suggests, to understand the aspects of an object hidden from sight one has to move and try all essential view points to complete the missing parts, being aware of the virtual existence of lines.

Thus, simplicity in the organisation of the grid system achieved through a co-ordination of grid lines under the same property facilitates the reading of the grid system and limits the different points of view one has to try through movement to as few points as possible.

It seems that simplicity is what Botta seeks by the subordination of the grid elements into the properties of a simple object, the block itself. Further, by using the same properties to organise both the shape and the grid geometry, he strives for the most possible realisation of this simplicity. Both systems are read as one and axial co-ordination eases the understanding of their structural properties. Thus, the synchronisation of both levels of properties strengthens the role of the axis and raises it to the level of observable properties.

Le Corbusier adopts a more complicated approach that creates a dissociation between the two levels of properties. Thus, he disconnects the geometrical patterns of the initial solid from the geometrical patterns of the rest of the shapes but he associates the former with the patterns of the grid structure. When the two levels of properties do not coincide the eye, attracted by the asymmetries of the configuration seen as an arrangement of shapes, does not immediately recognise the hidden order of the grids.

As it was suggested in the literature review chapter Colin Rowe has also observed the regular geometric patterns of the structural grids and the lack of such regularity in the configuration of both the interior and the exterior space of Villa Stein[50].

This analysis clarifies that what Rowe called a simultaneous application and denial of rules is about an absence of co-ordinated symmetry between the shape and grid properties.

Since his article 'The Mathematics of the Ideal Villa and other Essays' attention is drawn to the contradiction inherent in the ordered geometrical skeletons of the Corbusian villas in relation to the asymmetrical arrangements of their wall systems. This contradiction, is often stressed, allows for a 'disciplined improvisation'.

'The pure cube and the regular grid provide a discipline within which the size, position, and degree of penetration of voids can be determined by improvisation, following the suggestions of the plan'[51].

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49 E. H. Gombrich, Ibid., p. 211.

50 C. Rowe, Ibid., p.12.

51 A. Colquhun, 'The Significance of Le Corbusier', in the book 'Modernity and the Classical Tradition';The MIT Press, Cambridge, Massachusetts, London, 1989, p. 169.

All interest in studies on Le Corbusier and particularly in studies on Villa Stein is attracted by the geometrical order of the grids as providing an underlying canvas that sustains an ordered and balanced asymmetry. These studies have not attempted a detailed analysis of how this balanced asymmetry is developed during the transformation of the design, staying only at the level of the final result of the transformation process.

This analysis examines how these symmetries are constructed revealing some further complexities of the geometrical organisation of his buildings and of the role they play in the ways they become intelligible. Thus, it shows that this development is not achieved systematically and it is not applied in every analytic stage.

In LH1 symmetry of the larger grid system is developed at the last stages. In LH2 and LH4 it is applied throughout the analytic stages. Finally, in LH3 it is limited at the first and middle stages organising only the largest volumetric elements.

Thus, in LH1 the overall geometrical structure is crystallised at the end of the design process. It seems that the architect has no pre-existing intention to impose the geometrical properties of the block realised into a specific B F B F B grid to the manipulation of the volumes. The overall symmetry along the BF axis is created at the end and it emerges by the process itself[52].

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52 Marc Dubois in an evolutionary study of Villa Stein's development, through an examination of the earlier proposals, points out that inspite of the historical model revealed by C. Rowe the final form of the grids was found 'after intense travail patient' during which 'the Palladian grid gradually crystallised, only at a very late stage acquiring the striking correspondence with the Malcontenta'. Marc Dubois, '2 into 1', The Architectural Review, Volume CLXXXI no 1079, p. 36/1.

Besides, Le Corbusier himself demonstrates this point in his writings where he describes the role the 'regulating diagrams' play in his houses[53]. In 'The Modulor' he writes:

'A regulating diagram is not by nature a preconceived format; the architect chooses one type or another in accordance with the character of the design. The regulating process, based on a geometric equilibrium, thus merely order, clarifies, and purifies the design that has been already drawn up'[54].

In LH2 and LH4 the structure of the grids is controlled by symmetry in every stage revealing that there is an underlying intention to impose the properties of the block to the articulation of the grid. In LH3 there is an intention also which, however, limits itself at the first and the middle stages.

Nevertheless, analysis showed that although three of the buildings employ symmetry and tripartition of the large system they do not allow a vertical integration of the volume along a single organising axis and a single geometrical bay. The individual floor levels are treated as independent systems that exhibit either asymmetrical organisation or symmetry and tripartite development along a different direction. On the other hand, in Botta symmetry and tripartition of the building as a whole from left to right becomes an overall statement organising the grids of the individual floors also.

Besides, analysis of the relationship between the structural and the physical grids showed that Le Corbusier treats these grids as independent systems also built along the contrast of the repetitive character of the former and the hierarchical tripartite character of the latter. This shows that he constantly creates systems that can function together by a certain rule while at the same time they operate independently governed by another property.

The independent treatment of the structural and physical grids seems to demonstrate Le Corbusier's constant preoccupation with dissociations of systems, something that the Do-mino structure has offered to a great extent. 'The pillars left the outer partitions and calmly stood in the middle of the rooms. Then they left the inner partitions, the chimney left the walls, the staircases became free organs in the house and everywhere these organs took an individual character'[55]. This analysis seems to demonstrate that his

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53 The notion of the 'regulating diagram' appears in his writings as a regulating device that is analogous to the notion of the geometrical grids of this analysis. '...some sort of family relationships between the different elements, particularly between what the eye perceived immediately, the outline of the facade, and what it perceived next, a projecting wing, and what it perceived afterwards; the door and window openings and their surrounding wall surfaces. I needed a regulating diagram: a diagram based on diagonals, for a diagonal can express the special character of a surface by a single line'. Le Corbusier et P. Jeanneret - 2e Serie, Paris: Albert Morance, 1929 p. 14.

54 Le Corbusier, 'The Modulor', Cambridge Mass: The MIT Press, 1968, p.34.

55 Maurice Besset, 'Le Corbusier, To live with the light', The Architectural Press limited, 1987, p. 40.

design logic creates independent systems that do not limit themselves to the plastic treatment and to the individuation of the pictorial elements, but they concern deeper relations of the geometrical organisation of his houses.

Besides, the horizontal division of the volume into separate grid structures seems to suggest a profound tendency that favours the two dimensional geometrical planning over the three dimensional one, i.e. the treatment of the house as a set of layered two dimensional elements. Le Corbusier himself has stressed the importance of the plan by saying that : 'The plan is the generator'[56].

Rowe also suggests that the horizontal slab system of villa Stein achieving no dominance of the vertical direction and compared to the arched forms and pitched roofs of villa Malconteta exhibits a sort of vertical 'paralysis'[57]. This paralysis is evident from the inside where the equal distance between the floor and the ceiling makes all spatial points of the interior equal disturbing any three dimensional integration of the floors around a focal point[58].

However, these two dimensional plans are held together by an underlying general grid system that establishes connections across floors constantly regulating and adjusting the elements to comply with the overall geometrical order. This procedure seems to be based on a planning that develops each floor grid on a separate piece of tracing paper and then by superimposing one layer on the other it modifies them aiming at both coincidence and differentiation, autonomy and co-ordination of the various systems.

Le Corbusier himself has stated that the integration of these plans to the building as a whole is achieved through the regulating geometry governing the floor plans. He has showed his preference to regulating diagrams that achieve a global control over the contingencies of each horizontal floor. Referring to villa Stein he writes:

'The design of the entire house was governed by rigorous regulating diagrams that had the effect of modifying the dimensions of the various parts - sometimes by one centimetre (less than 1/2 in.). In a case like this mathematical laws are reassuring: when your work is finished, you know it is exactly right'[59].

Thus, whereas in Botta there is a hierarchical application of rules from the beginning to the end and from the largest to the smallest component, in Le Corbusier there is a lack of such hierarchical application. In

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56 Le Corbusier, 'Towards a New Architecture', William Clowes &Sons, p. 45.

57 C. Rowe, Ibid., p. 12.

58 Ibid., p. 12.

59 Le Corbusier and P. Jeanneret, Ouvre complete de 1910 - 1929, by W. Boesiger and O. Stonorov, Zurich: Erlenbach, 1937, and Artemis, p. 144.

Botta the rules seem to be determined at the beginning and the volume in process simply realises and articulates these rules. In Le Corbusier in spite of intentional symmetries, decisions are taken during the process determining what is symmetrical and what is not and which axis of symmetry prevails over another. There is rather a pre-existing general intention to regulate and impose a certain order to the grids rather than a specific formula that chooses one principle from the beginning and applies it up to the end of the design process.

Thus, Botta aims at the three dimensional integration of the buildings along the BF axis and the central geometrical bay leading the articulation of each horizontal layer towards this precondition from the beginning to the end of the design. Le Corbusier, on the other hand, adjusts the articulation of the layers to meet the requirements of a geometrical grid that emerges during the process.

Thus, the composition of 'ordered asymmetry' presents with inherent complexities even at the level of the 'rational order' of grids. This creates intrinsic difficulties in deciphering the logic of the hidden geometrical system. The observation of grid symmetry is not only disturbed by lack of shape symmetry but also by the dismembered elements of the grid that pull themselves into their own arrangements. The clearest possible example is given by the symmetrical arrangement generated by grid lines belonging to different floor levels, like the extended first floor terrace and the elliptical studio of villa Stein, (TLH1 3.3, fig. 30, p. 197) or the two longitudinal terraces of Villa Baizeau, (TLH4 3.3, fig. 28, p. 202).

The intrinsic complexities of the grid network as well as the apparent lack of symmetries at the level of the directly observed shapes disrupt an immediate understanding of the overall symmetrical organisation of the geometrical grids. The viewer wanting to decipher the geometrical logic of this network has to be engaged into a systematic and extended observation. During the process of decipherment he gradually realises that he is absorbed into an endless enterprise in which one possible interpretation is refuted by another and his mind can never rest on a final reading that summarises and compensates the adventures of the process.

In the context of these observations, the hypothesis expressed at the beginning of this chapter seems to be valid: *Botta creates a unity of perception based on a static appreciation. Le Corbusier creates a multiplicity of perception based on a dynamic exploration.*

## SUMMARY AND CONCLUSIONS

In this section the analysis returns back to the design devices the two architects use. The aim is to give an account of the compositional logic of Botta and Le Corbusier as well as to relate this logic to the ways their buildings become intelligible. In order to do this a brief summary of the findings of this analysis is needed.

- **MARIO BOTTA**

The analysis of the four houses of Botta points out the following:

- There is a consistent pattern of transformation based on a preservation of all levels of properties of the first stages.
- There are recurrent operations occurring in a systematic order.
- There is a constant association among particular stages, particular operations, particular shapes and particular combinations.
- In both physical and geometrical properties there is a single rule that is preserved and hierarchically applied from the general to the specific state.

At the level of the physical properties this rule specifies the physical demarcation of the block and directs the volume in process to fit this requirement. At the level of the geometrical properties it specifies the symmetries of the block and the volumetric U. The following stages are directed to meet the requirements of these properties. The hierarchical application of a single rule from the higher to the lower structural concepts creates a co-ordination of these concepts under a single organising pattern.

Thus, Botta develops a design logic that comprises a certain course of action, a set of operations and a specific vocabulary consisting of certain shapes and permutations. It also comprises associations among stages, operations, shapes, and combinations as well a global-to-local rule[60] by which elements are combined. The systematic employment of this logic reveals that he works within a pre-ordered system that encodes knowledge of how operations, shapes and combinations come together to produce a house.

Both the general framework of the initial state and the specific framework of the final state of his houses seem to have been established in an abstract general world. This world seems independent from the specific world of the design of a particular house with its given constrains and limitations and its own internal problems arising during a design process. In this respect, the buildings look similar to each other. Thus, there is no diachronic development of a design logic produced from the design of each house

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60 A rule that is applied from a higher to a lower order concept or from a higher to a lower stage of a transformation process.

to the other. There seems to be a fixed logic producing houses that satisfy a pre-existing knowledge of a building form.

- **LE CORBUSIER**

Analysis of the four houses of Le Corbusier points out the following:

- There is a consistent pattern of transformation based on a preservation and a suspension of the properties of the block operating in all three layers of properties.
- There are recurrent operations occurring In a specific order. This order is based on an alternative application and suspension of the properties of the initial solid.
- There is not a consistent pattern of association between stages, particular shapes and particular combinations. However, there is an association between particular stages, particular 'types' of shapes and 'types' of combinations. Thus, there are differences in appearances of shapes used but there is also an underlying similarity regarding the general category these shapes belong to.
- At the level of the physical properties there are rules that decompose the block and rules that restore its physical demarcation to comply with the properties of the initial solid. At the level of the geometrical properties there are rules that apply the axial symmetries of the initial solid and rules that suspend them.

Like Botta, Le Corbusier establishes a design logic that comprises a course of action, a set of operations, shapes and combinations. However, unlike Botta, who uses a restricted vocabulary of shapes and combinations, Le Corbusier develops a larger reprertory of shapes and permutations. Besides, as opposed to Botta who uses a single rule, he does not apply a single hierarchical principle creating both co-ordination and differentiation among the higher and lower structural concepts.

Botta employs a straightforward syntax encoding knowledge of a single way of transformation. In contrast, Le Corbusier employs an implicit syntax that offers a range of ways of sculptural articulation. Botta gradually reduces the field of possible solutions by the application of the single rule. Le Corbusier opens this field of solutions by a constant suspension and inclusion of rules.

Thus, as opposed to Botta who works within a pre-ordered system, Le Corbusier works within a system that provides implicit knowledge of a range of ways that sculpture a house form. Whereas Botta knows how to structure the transformation process to satisfy pre-existing knowledge of a building form, Le Corbusier knows how to direct the transformation process to release a potential energy in form.

The systematic employment of a particular design logic by these architects shows that they are both conscious about the possibilities of their manoeuvres. However, Botta maximises the control of the external world over an internal word of possibilities that emerge during the design process. Le Corbusier explores these possibilities and puts the two worlds into a internal negotiation. It is at the end of this process that he develops a global knowledge of his forms because it is only then that the rules are crystallised into the specific form of the building.

'One has to discover the latent geometric law that governs and determines the character of the design. At a certain moment it will spring to mind and unify all the parts. There will be a few adjustments, a few correlations, and a perfect harmony will finally prevail'.[61]

Therefore, whereas Botta puts emphasis on the subordination of the design process to the requirements of an explicit syntax, Le Corbusier puts the emphasis on the process itself and on the potentials it releases.

- **Summary**

To recall, analysis showed that the design logic of these two architects influences the ways their buildings become intelligible. The design logic of Botta based on pre-established rules that are hierarchically applied creates a formal system that is immediately understood from an almost single position. The design logic of Le Corbusier based on pre-established as well as on emergent rules creates a formal system that is deciphered through movement and an intensive exploration. In his effort to comprehend the Corbusian buildings the observer realises that the tension arising from the multifaceted and complementing concepts is never resolved into a static interpretation of the whole under a single principle.

The examination of formal properties of the interior of these buildings in the following chapter will extend this inquiry further.

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61 Le Corbusier, 'Towards a new Architecture', William Clowes & Sons, 1970, p. 65.

# Chapter Four

# PLAN ANALYSIS

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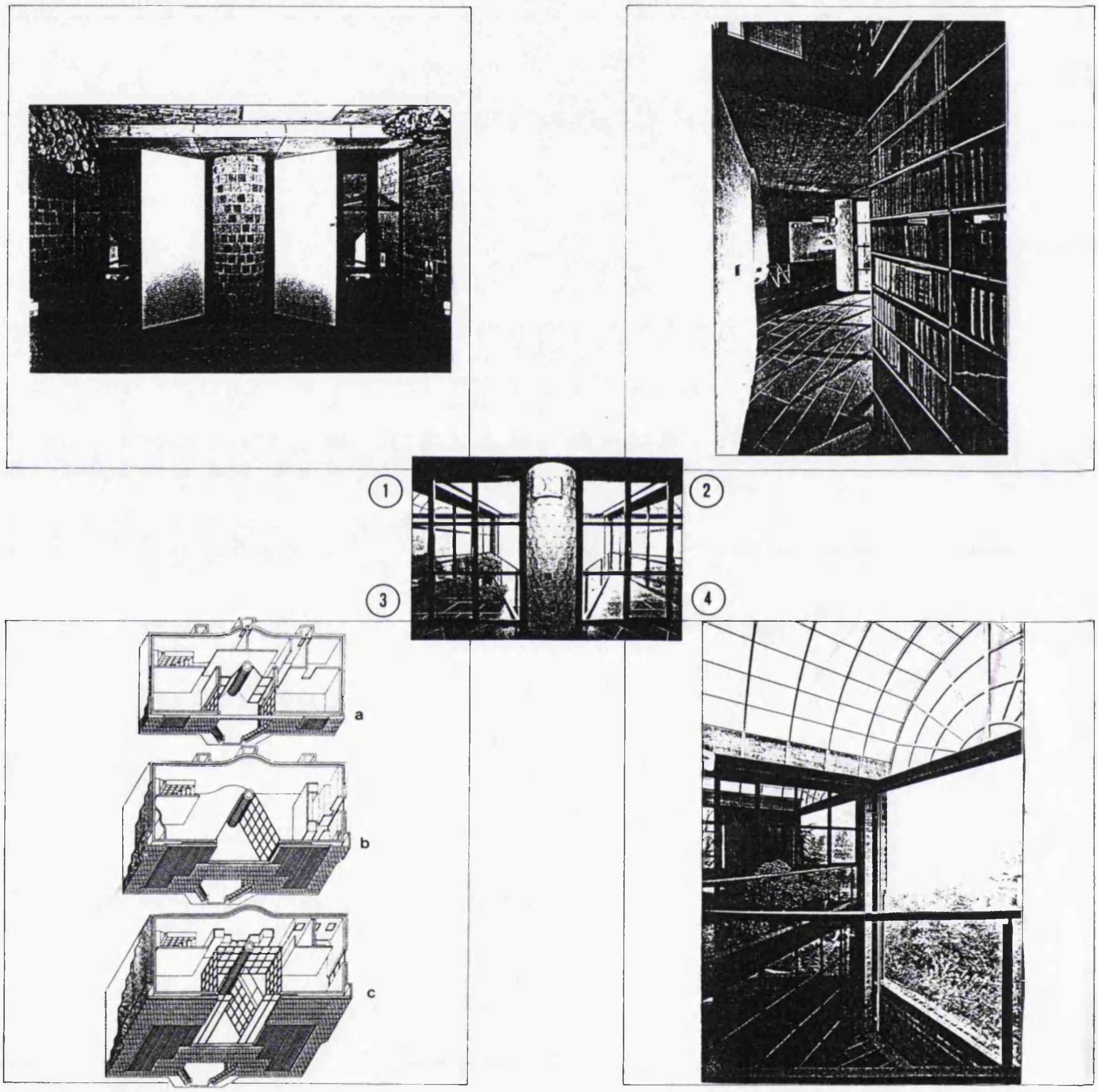

# • INTRODUCTION

## • How interiors are understood in plans

It has been suggested that a description of interiors needs to explain two things: How they are seen simultaneously as arrangements of shapes, lines and points in two dimensions and how they are seen gradually as systems of visual episodes that are exposed through time. It is the first question this chapter attempts to answer[1]: *How the internal organisation of buildings is understood as a formal arrangement represented in plans*

A plan works in two ways: First it works within the formal constraints of a two dimensional surface. Second it operates within the constraints of a three dimensional representation of space. Together with the two dimensional organisation of shapes plans bring space into the flat surface in a way that is similar to a painting. Devices like interlocking shapes have been shown as creating a figure-ground phenomenon in which elements assume foreground or background positions. These devices are often used in architectural representations bringing depth into the drawing and creating the illusion of three dimensional space. A second question, then, that arises is: *How this virtual space interacts with the two dimensional extension of space organised by shapes, lines and other elements in a plan*

To clarify these questions analysis moves from the exterior to the interior of the buildings of Botta and Le Corbusier. Its objectives are also:

- To examine how the internal organisation relates to the external organisation of these buildings as this was described in the previous chapter.
- To extend the analytical methods used in the analysis of the volume to an analysis of the plan.

## • Formulating a hypothesis - a first description of similarities and differences

Before moving to the analysis a first description of similarities and differences is attempted with a view to form a hypothesis regarding the questions addressed in this stage. Starting with how the interiors of these buildings are understood as formal organisations in two dimensions, a number of initial observations can be drawn in relation to the ways these architects approach the physical and the geometrical articulation of their plans.

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1 In the following chapter analysis will examine the ways the interior is understood sequentially as one moves inside it.

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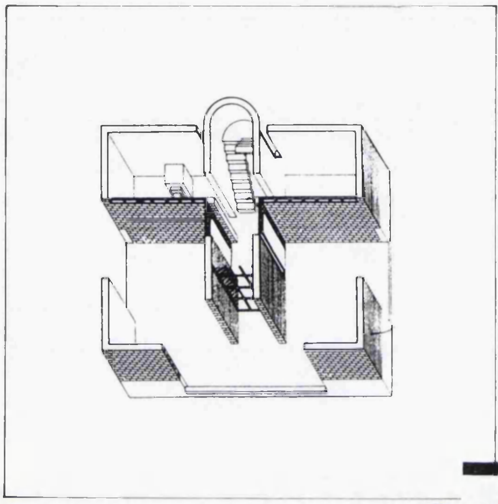

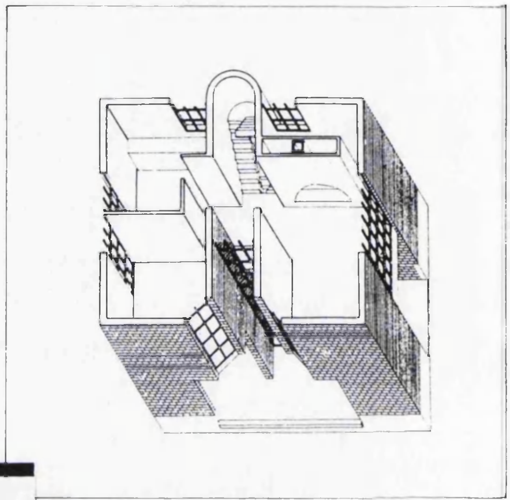

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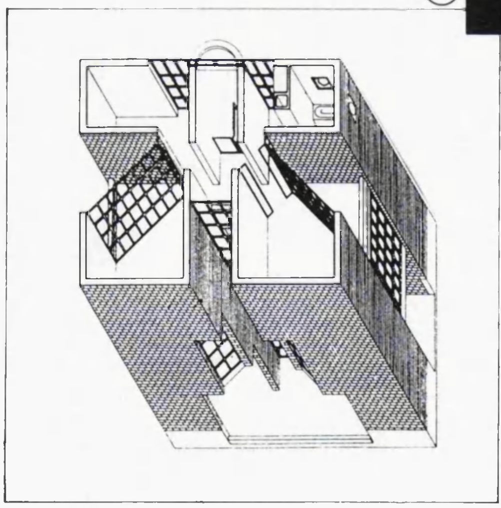

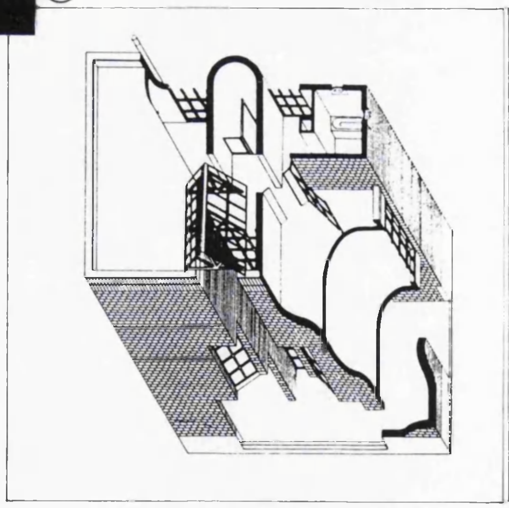

- **Physical articulation and the two dimensional extension of space**

It was suggested earlier that Le Corbusier's do-mino skeleton enabled a decomposition of his volumes into planar and columnar elements. It also enabled a separation amongst the external surfaces, the columns and the inner partitions, (illustrations 4.19, p. 230, 4.23, p. 231, 4.27, p. 232, 4.31, p. 233). On the other hand, the load bearing walls of Botta demand an integration of the outer and the inner surfaces with themselves, (illustrations 4.3, p. 226, 4.7, p. 227, 4.11, p. 228, 4.15, p. 229).

However, Le Corbusier breaks space down to bounded regions. In contrast, Botta creates a unified interior often lacking clear distinctions between regions of space. *Thus, a paradox seems to arise in which Le Corbusier's 'free plan', which is often associated with unlimited spatial extension, is about space that is subdivided into individual rooms. Botta's load bearing walls, which are often seen as constructing a strict separation of spaces, are combined with space that flows unrestricted by inner partitions.* It is hoped that analysis will clarify these contradictions examining how the notions of the 'free plan' and of the load bearing walls are addressed by these architects.

Another fundamental difference between Botta and Le Corbusier refers to the shapes they use. In the former the internal walls define simple shapes that are clearly distinguished from each other, (illustrations 3. 16, p. 156, 3.20, p. 168, 3.24, p. 169, 3.28, p. 170). In the latter certain surfaces define simple shapes, while others form complicated configurations that seem fastened together by a mutual penetration of parts, (illustrations 3.32, p. 175, 3.36, p. 194, 3. 40, p. 195, 3.44, p. 196).

The serpentine movements of Le Corbusier's surfaces accommodating niches, wardrobes, chimneys and other elements of daily use create a variety of small scale incidents that makes each space and each house different from the others. Botta's surfaces do not seem to capture the eye in the way the sculptured walls of Le Corbusier do. Nothing in their configuration can create a point of reference that distinguishes each house from the others.

*The subdivision of the interior, the complex shapes and the sculptural gestures of the walls in Le Corbusier emphasise the small scale articulation. The unification of the interior into a single flowing space and the simplicity of the shapes in Botta put an emphasis on the large scale.*

It seems that variety and the complexities of the small scale make the Corbusian plans difficult to comprehend. One may need to look at them many times for new points of view seem to arise. The complex interaction of interpenetrating shapes demands the necessity to focus on each shape separately until the others fade into the background. Once an interpretation is reached it is immediately contradicted as soon as the eye departs towards other areas of the plan. On the contrary, Botta's plans rarely absorb attention by the details of their configuration. Their simplicity releases inspection and the eye captures a sharp clarity of the configuration as a whole.

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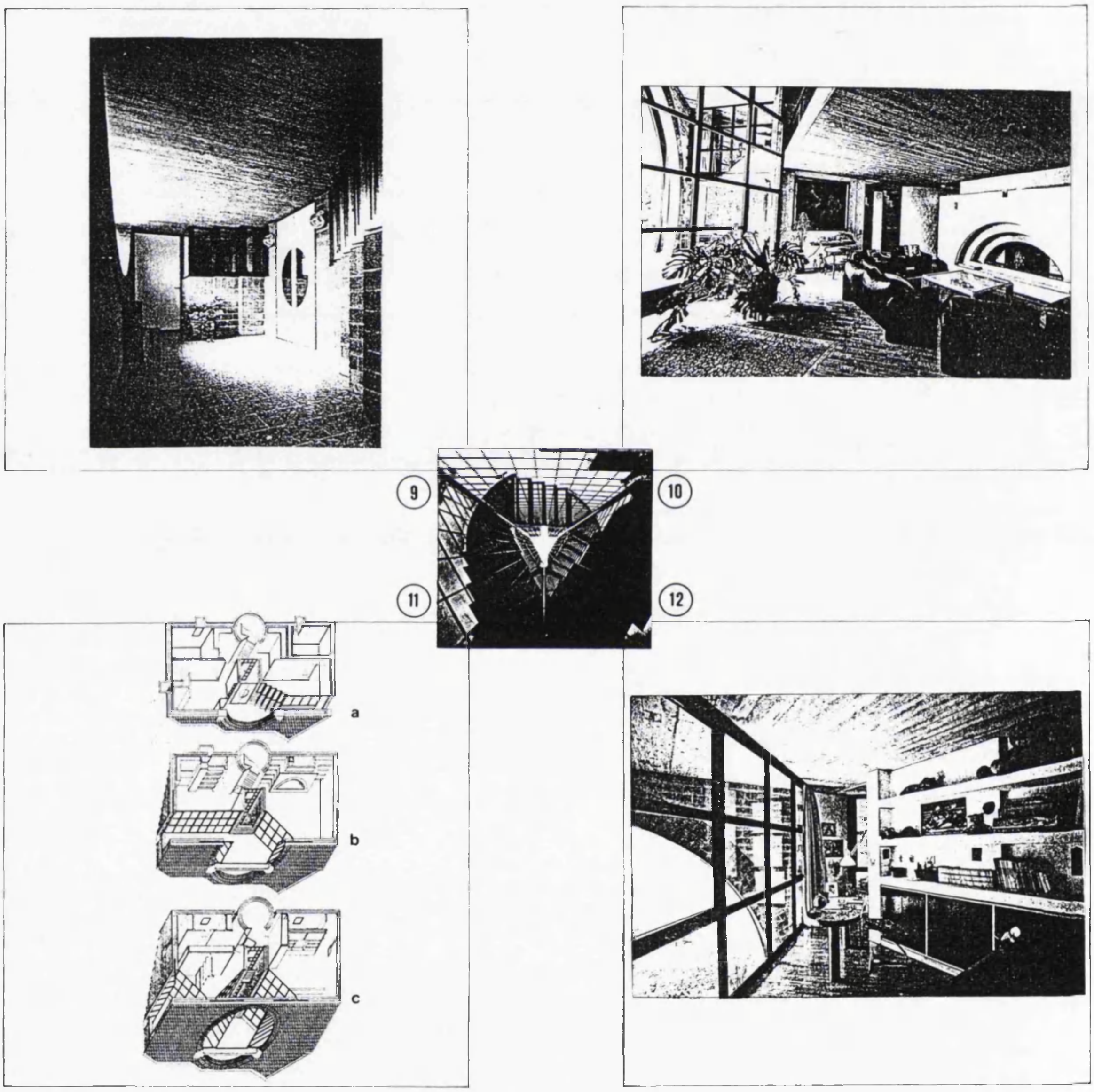

- **Geometrical articulation and the two dimensional extension of space**

In Botta's plans centrality seems evident. The staircases, the voids, the terraces and the spaces of the interior are all centred around the back to front axis, (illustrations 3.16, p. 156, 3.20, p. 168, 3. 24, p. 169, 3.28, p. 170). On the other hand, the viewer examining Le Corbusier's plans observes a lack of centrality in organisation, (illustrations 3.32, p. 175, 3.36, p. 194, 3.40, p. 195, 3.44, p. 196).

Colin Rowe identified centralised tendencies in Le Corbusier based on the geometrical ordering of the structural grid[2]. Volumetric analysis also identified the existence of symmetries in the organisation of his grids. However, the grid elements were found to enter into symmetrical relations with respect to a different axis in each floor. Besides, they were shown to be hidden behind the asymmetrical arrangement of physical articulation. Symmetry, it was argued, becomes an organisational principle that is difficult to grasp.

Similarly to the exterior, the geometrical organisation of Le Corbusier's grids in the interior seems hidden behind the sculptural asymmetries and the planar ambiguities of the walls. In Botta this organisation is evident. It is about a centrality which absorbs attention and reads as the final statement of the plan.

Botta's plans sustain no conflict. The edges and the centre interact in harmony. This harmonious interaction forces the viewer to look for some discrepancy finally discovered at the small scale incidents occurring at the back of the composition. In contrast, Le Corbusier's plans have no simple and clear geometrical rule organising them as wholes. Finding no access to any kind of classification, one looks at the outer limits of the composition where the edges of the volume wrap around the elements putting an end to the conflicts created inside the surface of the plane. Thus, it is a point of reconciliation the viewer looks for in Le Corbusier's plans. On the other hand, it is conflict that is sought in Botta's interior.

- **Physical articulation and the variable of spatial depth**

It has been said that Le Corbusier uses complex arrangements of overlapping and interpenetrating shapes. The piano shaped elements of Villa Stein, for example, overlaps with the fluid space of the sitting area implying a plane that is placed in front of the plane defined by the interior space, (illustration 3.32, p. 175). Another example is given by the interlocking private rooms in villa Meyer which intrude into each other's space interchanging positions in depth, (illustration 3.40, p. 195).

Overlap and interlocking shapes are devices that are often associated with the expression of depth in pictorial representation. They create the illusion of intervening space constructing a figure/ground situation in which none of the elements is unambiguously figure or ground.

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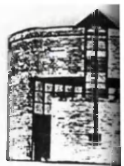
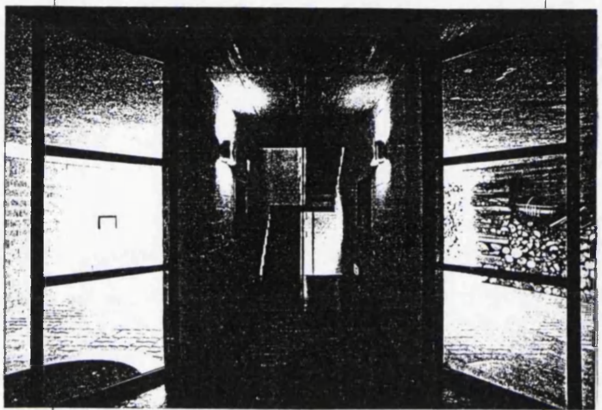
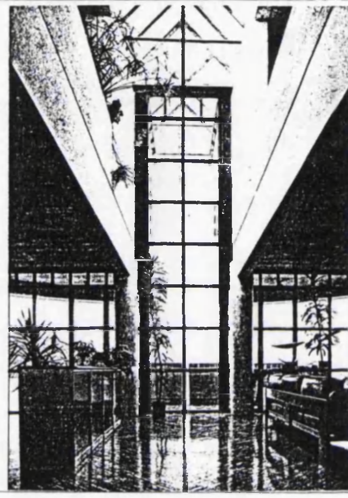
2 Colin Rowe, 'The Mathematics of the Ideal Villa and Other Essays', The MIT Press, 1984, p. 4.







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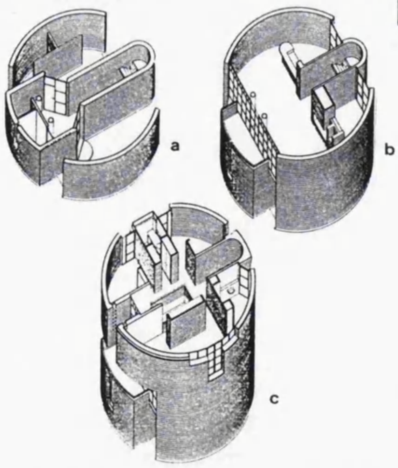


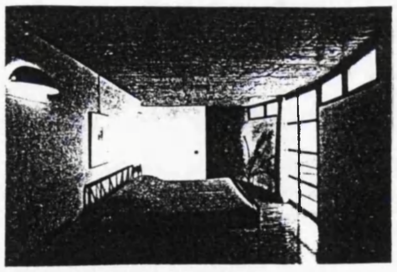

It has been mentioned earlier that Rowe and Slutzky have illustrated that the Cubist's preoccupation with interpenetrating planes is analogous to Le Corbusier's preoccupation with interpenetrating vertical surfaces[3]. A first description carried out in this stage identifies also an association between the Cubist's overlapping shapes and Le Corbusier's fluctuating shapes on the plan.

Botta uses also pictorial devices to suggest continuity of space and boundaries. At the house at Massagno, for example, the partitions at the right side of the second floor read as figures against the ground of the bedroom's space, (illustration 3.24, p. 169). Nevertheless, regardless of such devices, Botta does not share Le Corbusier' s extreme preoccupation with a complex interaction of elements.

The plan's conventional role is to express the organisation of space in the horizontal direction. However, these architects juxtapose the two dimensional spatial extension with a three dimensional virtual space. *Thus, they seem to treat their plans as canvases for spatial expression parallel to their role to represent an horizontal arrangement of spaces.*

Le Corbusier believed that architecture is anticipated through walking. This experience, he said, is quite the opposite of the experience of 'Baroque Architecture that is conceived on paper from a theoretical view point'[4]. His conviction on the difference between architecture seen through movement and architecture seen on paper was stressed in his work through a series of ramps and staircases that formed the elements of a promenade architecturalle.

Botta's houses do not express an emphasis on a promenade. However, a careful planning of views from the interior of his houses to the landscape shows a concern for what one sees moving inside these buildings, (illustration 4.4, p. 226, 4.12, p. 228, 4. 14, p. 229). In this way, he is also preoccupied with those aspects of architectural experience that are not captured by an arrangement of lines and shapes on a plan. Thus, another paradox seems to arise: *although both architects recognise that experience of Architecture lies in walking, they treat the surface of their plans as a canvas for illusions of space.*

- **Two dimensional and three dimensional extension of space**

At this point the discussion returns to the horizontal organisation of these plans and to the ways it interacts with the expression of virtual space. Searching beyond spatial depth to read the geometrical principles that link the elements together, one abandons the third dimension to inhabit the second one. Thus, geometry is read as a property of the surface rather than as a property of deep space.

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3 Colin Rowe, Robert Slutzky, 'Transparency, Phenomenal and Literal', in the book 'The Mathematics of the Ideal Villa and Other Essays', The MIT Press, 1984.

4 Le Corbusier, Oeuvre Complete, II, p. 24.

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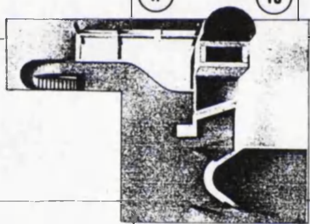

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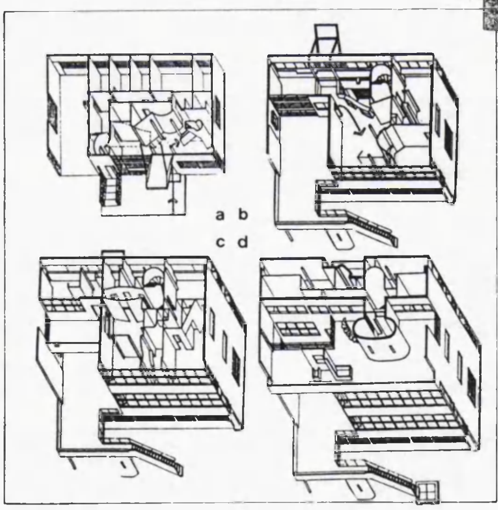


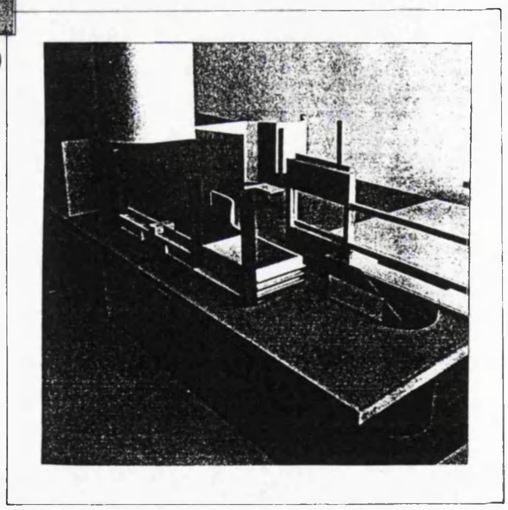

In Botta simplicity in the structure of implied depth seems to accommodate the horizontal readings with easiness. The geometrical clarity of these readings based on centrality makes the configuration immediately understood. In Le Corbusier the complexity of the pictorial space captures the viewer's attention. The absence of centrality in horizontal organisation creates a difficulty in understanding the plan. In It seems that in Botta the interaction between the flat and the deep extension of space aims for wholeness and clarity of interpretation. In Le Corbusier none of the two situations allows a possibility to grasp the configuration at once.

- **Hypotheses and arguments - a brief summary**

Completing the course of this description some hypotheses can be reached supported by the observations presented above. It has been said that Botta's plans are characterised by an emphasis on the global scale organisation through symmetrical relations amongst simple shapes. It has been also mentioned that Le Corbusier's plans are intricate articulations of interlocking shapes lacking a recognisable overall geometrical pattern.

The organisational differences between the two architects can be interpreted as creating two different systems of intelligibility. *Botta creates plans that are grasped at once as single unified systems with an axis of symmetry. Le Corbusier designs plans that lack a single coherent reading as wholes. Instead, they encourage multilayered interpretations that are in a constant state of conflict and unresolved tension with each other.*

In both architects there is a concern for architecture seen in movement and architecture seen in the pictorial way. The contradictions emerging from these conflicting attitudes in the case of Le Corbusier can be illuminated by diverting into the ways Cubist paintings articulated pictorial space.

Cubist artists arrived at a new conception of space through points of view that were multiplied to suggest a virtually mobile observer. They compressed pictorial depth into a shallow stratum in the need to demonstrate the contradictions inherent in looking at a three dimensional space through a flat medium.

Le Corbusier's pictorial space encompasses fluctuating planes in a manner similar to Cubism. The perceptual ambiguities of deep space and its complex two dimensional organisation seem to refer to the contradictions of flat representation, as Cubists painting do. Aware of the flatness of his drawing surface, Le Corbusier seems to propose that what plan is about, is *deception.*

By saying that architecture is seen through movement and by designing complex plans that imply an observer in a state of a virtual movement, Le Corbusier seems to enable the hypothesis: *The pictorial space on his plans is a visual metaphor of a dynamic experience of space based on movement and observation.*

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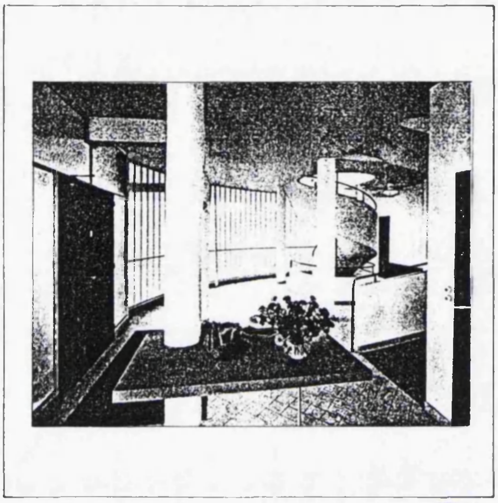

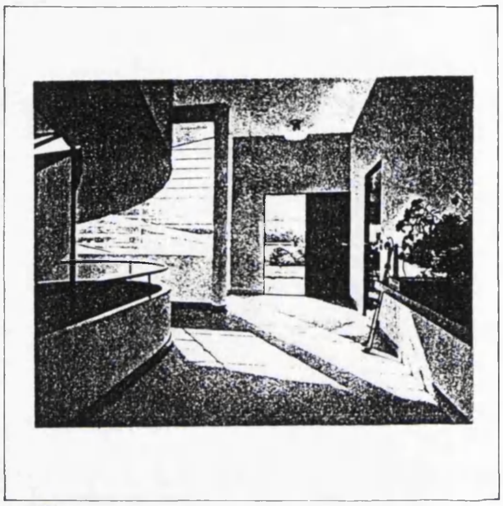

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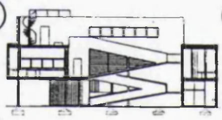

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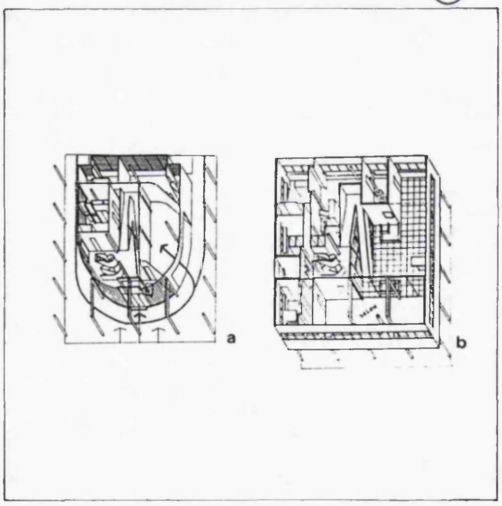
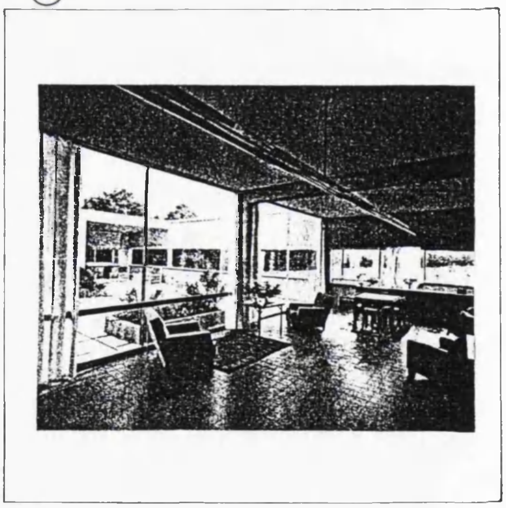


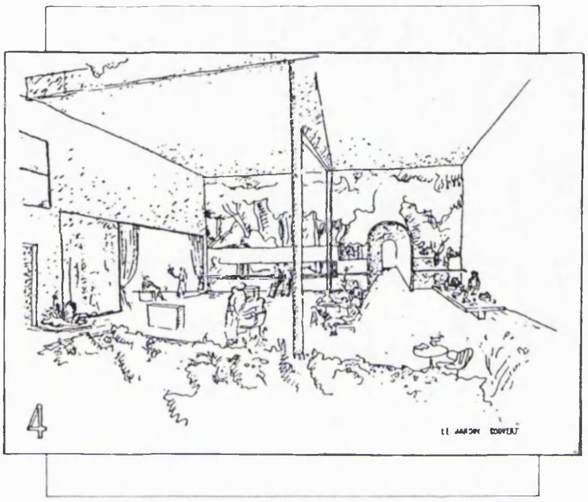



In Botta shapes are also *lifted* from the paper. However, ideas of complex shape interaction like the ones that preoccupy Le Corbusier's mind are absent from his plans. Botta's shapes read clearly as figures against the ground of a fluid space bound by the outer surface. It is this clarity that seems to suggest that *Botta tries to achieve a communicative plan that rigorously transmits the operational logic of real space.*

These hypotheses will be found as being demonstrable by the analysis carried out in this chapter. It will be shown that Botta organises elements according to an overall symmetry on a single axis. Le Corbusier works in a more complicated way allowing his elements to enter into more than a single relation.

Simplicity and overall symmetry emerges from the application of rules from the largest component, the outer boundary, to the smallest detail. Complexity results from a lack of systematic preservation of rules in the process of transformation. Botta directs the plan in process from outside-in, from the large scale of the volume to the small scale of the inner partitions. Le Corbusier enables the interior to develop independently of the restrictions of the external articulation. The unity and wholeness in Botta is a integral part of a compositional logic that is guided by a pre-conceived idea. Complexity in Le Corbusier involves a compositional attitude in which there is less space for pre-existing formulas and more space for exploration.

Finally, it will be also argued that pictorial depth in Botta is a means for satisfying the aspirations for a plan to become the carrier and the expressive device of architectural experience. In Le Corbusier pictorial depth is also an instrument of intention. It demonstrates that drawing is *deception* incapable of showing actual experience, as well as *expression* of a particular kind of spatial experience that is based on movement.

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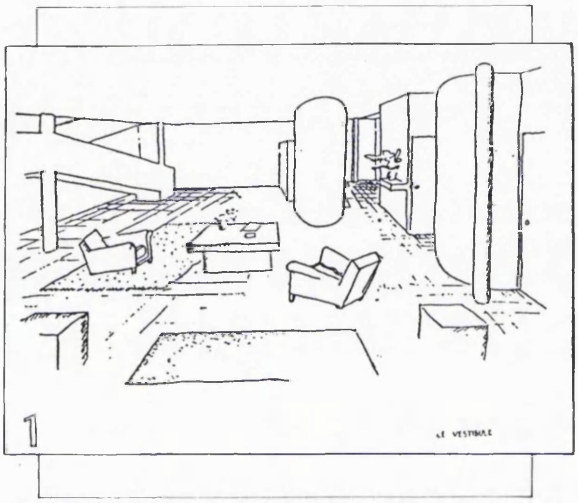


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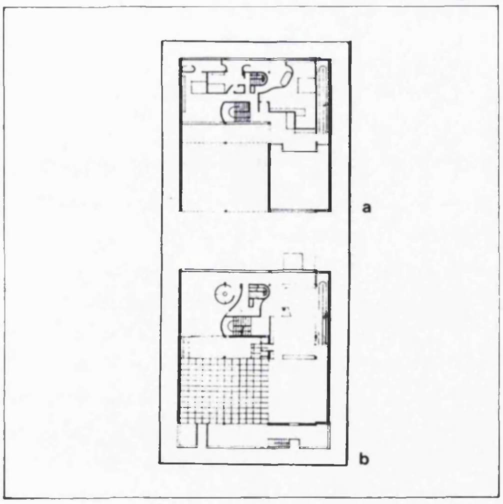


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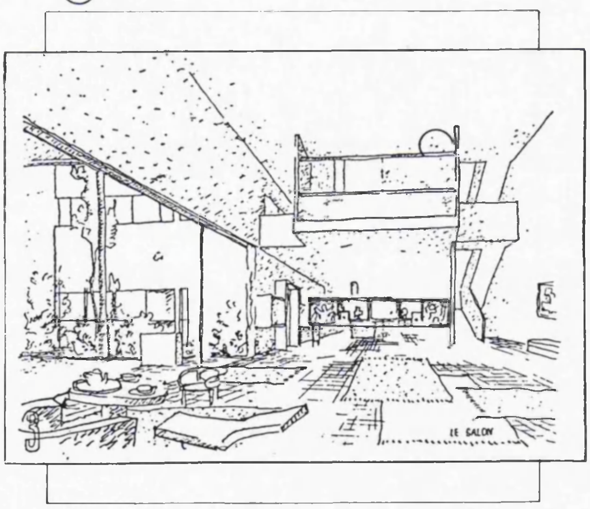

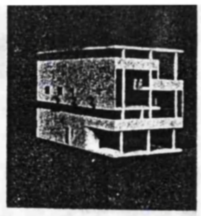

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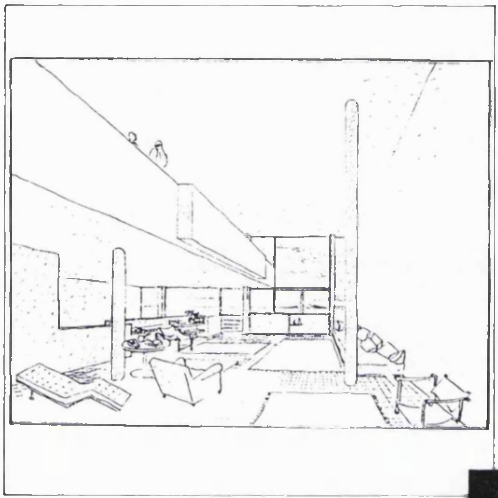

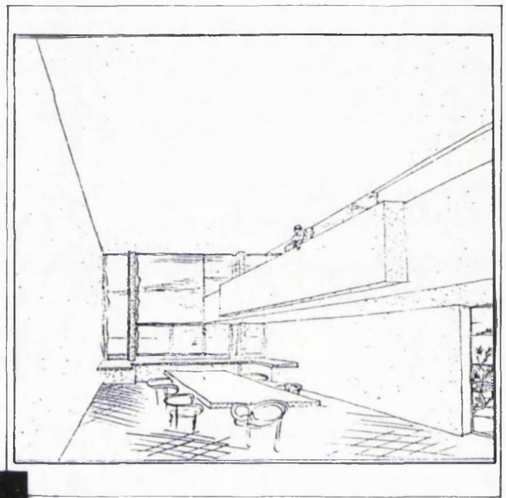

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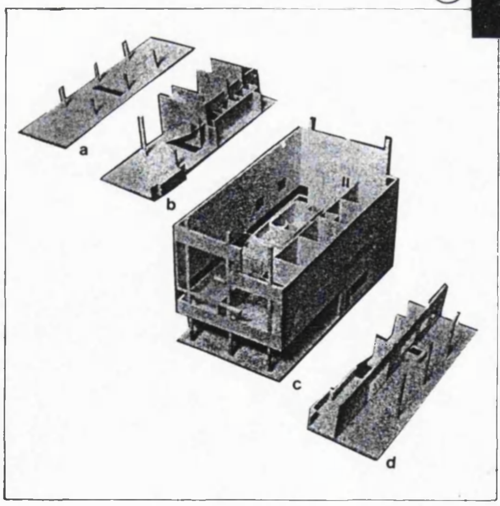


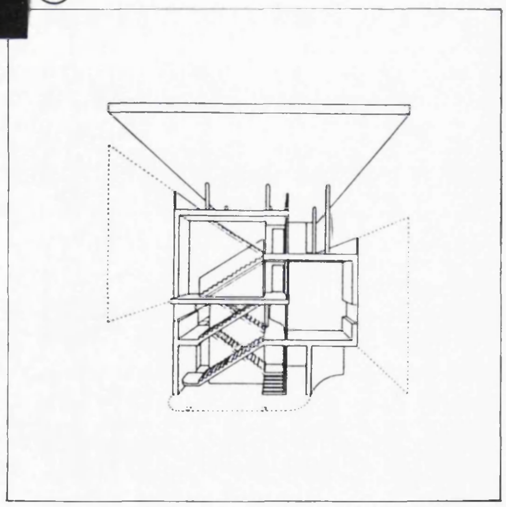

## DESCRIBING THE METHODOLOGY

- **Describing two dimensional formal properties as transformations**

This chapter extends the analytical method developed in the analysis of the volume to the analysis of plans. It also establishes a description of formal properties as transformations evolving in stages from higher to lower levels of two dimensional articulation. The first stage of this description is the last stage defined in the previous analysis. This is because analysis progresses from the outside to the inside and from the large scale of the volumetric articulation to the smaller scale of the internal articulation.

- **Definition of higher and lower levels of articulation**

Similarly to the previous chapter, stages are defined by the property of elements to be distinguished from each other entering into higher and lower levels of articulation. Thus, staircases are amongst the first elements to be considered in the transformation of the interior. This is because they link the horizontal floors together referring to the scale of the building as a whole. As such, they precede components of less global significance that occur in a single floor. An example of the ways in which staircases enter into the analytic description is given in TBH1 4.1, fig. 2, (p. 239).

Elements are considered as distinguished from others by virtue of their size and their property to interact with the large scale components of the external articulation. Large scale elements the defining lines of which coincide with the defining lines of the block and the outside space are also seen as belonging to the first stages of analysis. An example is given in figure 8 in TBH1 4.1, (p. 239). The rectangles on either side of the void are considered as belonging to higher levels of transformation than the ones situated at the back right corner, (TBH1 4.1, figure 9, p. 239).

- **Physical properties - physical recognisability of shapes**

Similarly to the Volumetric Analysis, formal patterns are described as an interaction amongst physical properties, shape properties and grid properties. Physical properties have been defined as referring to the physical demarcation of the surfaces, edges and vertexes of a shape that makes it appear as a physically identifiable entity. They are studied through a table of figures that present in two dimensions the transformation of the interior from the first to the last stage, (TBH1 4.1, fig. 1-9, p. 239).

It has been already suggested that when two or more shapes interact, like in figures 4.2, 4.3, 4.5, (p. 292), complementary readings are created questioning their recognisability as distinct physical entities. Studying the physical properties of the interior analysis moves into more complex interactions of shapes than those studied by the elementary examples of layouts and by the Volumetric Analysis. The problem that arises at this point is: *how the parameters determining shape recognition in complex arrangements of the interiors of houses can be defined?*

In this case analysis considers as clearly recognisable shapes those that have at least n-1 corners fully defined by physical elements, fig. 4.1, 4.2, 4.3, 4.5, (p. 292). This is because an implicit presence of the missing surface restores the physical coherence of the corner and, therefore, the physical coherence of the shape. Another requirement is that the surface defining the corner that lacks complete physical definition does not extend in a boundary continuous mode to define a larger shape, fig. 4.4, (p. 292). When this happens the continuous surface extending to complete the large shape decomposes the small one into an L shaped surface destroying its physical identity.

However, even physically recognisable shapes can be decomposed in planar components. In figure 2 in TBH1 4.1, (p. 239), for example, the shapes at the front left and right corner of the plan are clearly recognisable retaining physical definition of three of their four corners. However, glazed material analyses the front right and the front left corner of these shapes into planar elements. Their clarity as closed geometrical concepts interacts with volumetric and planar readings introducing a complexity into the configuration.

Thus, a second parameter that is taken into consideration is the complexity arising from the definition of shapes by certain material. Two different types of material definition are distinguished. One describes the type of material used operating along the opposition glazed/opaque material. The other one describes the thickness of the surfaces defining a shape operating along the opposition thick/thin surfaces. Both are represented in plans by an opposition between thick and thin lines, the former expressing opaque or thick walls the latter expressing glazed or thinner opaque walls.

- **Shape and grid properties - definition of 'just about' symmetry**

Shape properties are examined in relation to the symmetries of a configuration seen as an arrangement of shapes. Grid properties are analysed in relation to the symmetries of the grid elements generated by the extensions of the lines defining these shapes.

Volumetric analysis examining Le Corbusier's houses distinguished between the physical and the structural grid. The former is defined by the extensions of surfaces. The latter is defined by the extensions of lines that pass through the geometrical centres of columns. This distinction was essential to accommodate the separation of columns from surfaces and their organisation into a separate system. A similar dissociation between the vertical planes and the support elements in Le Corbusier's interiors imposes a consideration of both grids. In Botta the integration of the load bearing wall with the inner surfaces does not generate the necessity to distinguish between a physical and a structural grid. Shape properties and the properties of the two grids are each studied through separate tables of figures presenting the transformation of the interior in two dimensions, (Shape properties: TLH1 4.1, fig. 1-12, p. 262, Physical grid properties: TLH1 4.2, fig. 1-12, p. 263, Structural grid properties: TLH1 4.3, fig. 1-10, p. 264).

Analysis tries to take into consideration approximate descriptions of symmetry or *'just about' symmetry.* 'Just about' symmetry characterises a configuration when a large number of elements enter into symmetrical relations but there is no symmetry governing the configuration as a whole. The ratios of the number of elements, (shapes and grid lines), that are symmetrical on an axis to the total number of elements accounts for the degrees of symmetry in the configuration. These ratios are the ***Symmetry Shape index*** and the ***Symmetry Grid index.***

An assumption established to enable the identification of approximations of symmetry is: 'Just about' symmetry characterises a distribution of elements when over 70 percent of them are symmetrical on an axis. The Symmetry Shape index and the Symmetry Grid index are presented in separate tables, (TBH1 4.3 and TBH1 4.4, p. 240). For economy of description analysis will refer to these tables only in cases in which 'just about' symmetry is created. Otherwise it will simply identify the lack of overall symmetry without mentioning the Symmetry Shape index and the Symmetry Grid index.

- **Coincidence between the lines of the interior and the lines of the exterior**

Another parameter that is taken into consideration is the degree to which the lines generated by the surfaces of the internal articulation, i.e. the surfaces defining the rooms of the interior, coincide with the lines generated by the surfaces defining the external articulation, i.e. the surfaces defining the block and the voids. An example of such a coincidence is given in figure 2 in TBH1 4.2, (p. 239). In this figure the lines defining the rooms situated at the front left and right corners coincide with the lines defining the void at the centre of the layout.

This property of elements to interact with the global scale components is crucial for the identification of the ways the interior in process is governed by the rules of the exterior. The more this interaction takes place the more rules from higher levels are imposed on lower ones. To account for this, analysis calculates the ratio of the lines defining both the internal and the external surfaces to the total number of lines in the layout. This ratio is defined as ***Inside/Outside Line index***, (***I/O Line index***). Values close to 1 indicate that there is a coincidence between the lines of the interior and those of the exterior. On the other hand, values close to 0 mean that separate lines define the former and the latter.

- **Operations**

Three categories of operations are used by this analysis as transforming the interior of these houses. These are: *superimposition, addition* and *planar extension.*

*Superimposition* occurs when a shape with a clearly identifiable contour is superimposed on another one, (fig. 4.2, 4.3. 4.5, p. 292), in a way that the former creates an *interruption* of the space, fig. 4.5, (p. 292), or both the space and the boundaries of the latter, fig. 4.2, 4.3, 4.4, (p. 292). A more complex arrangement emerges in which the previous shape, the superimposed shape and the shape resulting from superimposition are physically present.

An example of superimposed shapes is given in figure 2 in TBH1 4.1, (p. 239). The two spatial rectangles situated at the front left and right corners are physically recognisable shapes by virtue of physical definition of three of their four corners. These shapes interrupt the continuous extension of the boundaries of the block as well as the continuous space defined by these boundaries as this features in figure 1 in the same table.

Addition occurs when an element is added to a shape interrupting its space and boundaries without forming a clearly recognisable spatial shape. In figure 4.4, (p. 292), for example the L shaped surface is considered as an element resulting from addition. Another example is given in TBH1 4.1 fig. 5, (p. 239), by the free standing partition introduced at stage two at the left side of the first floor plan. Both these elements register as lines rather than as closed and physically identifiable shapes.

Finally, extension takes place when one or more of the defining surfaces of a shape is extended outside its perimeter. An example of extension is provided in fig. 2 in TBH2, (p. 255). The curvilinear surface at the back of the layout is extended towards the interior. A blue/red colour distinction indicates the distinction between superimposition and addition/extension.

- **The structure of this chapter**

Similarly to the previous chapter, only a single house by each architect is analytically described. The remaining three houses are included in the appendix. However, all houses are covered by a comparative description supported by figures presenting the analytic stages which are reported in that appendix.

This chapter is divided into three main sections:

- The first one examines Botta's house at Viganello followed by a comparative examination of all of his houses.
- The second one looks at Le Corbusier's villa Stein separately as well as in comparison to his other houses.
- Finally, the third section compares the two sets of houses.

The examination of each of the houses is divided into three parts:

- The first part offers a general description of the interior without undertaking an analytic examination.
- The second part offers an analytic description of the properties of each stage progressing linearly from the generic to the specific state.
- The third part offers a comparative description of stages. This looks at those properties that are preserved from the first to the last stage and from each stage to the next.

Within this analytical framework and this structure of presenting the material analysis proceeds to the examination of the houses.

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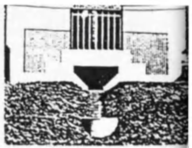
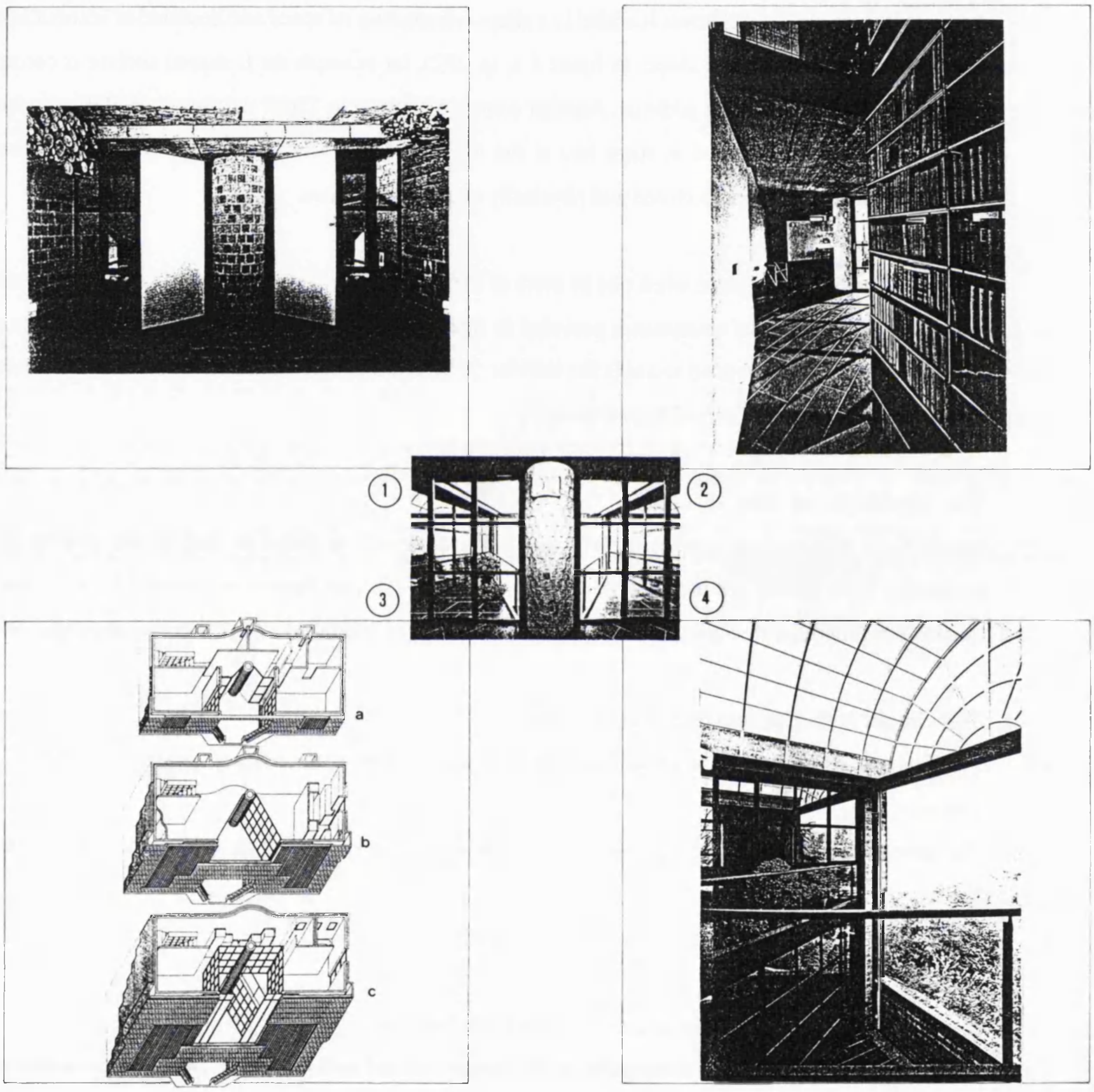




# ANALYSIS

## MARIO BOTTA - HOUSE AT VIGANELLO - (BH1)

- **GENERAL DESCRIPTION, (illustrations 4.1-4.4)**

Access to this house is through the loggia that cuts deeply into the ground floor, (Illustration 4. 3a). A linear entry hall arranged along the lateral axis leads to a staircase at the back left corner of the layout. Two rooms flank the loggia, while two service spaces occupy the back and the back right corner of the plan.

The glazed surfaces of the triangular terrace at the first floor intrude into the interior dividing the plan into living, kitchen and dining spaces, (Illustration 4. 3b). An outward curve of the back wall becomes a response to the intrusive force of the terrace. In accentuation of this condition the wall detaches itself from the ceiling to create a vertical link between the first and the second floor. This vertical connection is intensified by a zenithal light beam falling from the top to the second and first floors.

There are no clear boundaries separating one space from the other. Spatial flow is asserted by the uninterrupted extension of the ceiling over the entire floor area. Slate slabs that cover the floor surface emphasise spatial continuity further. The same material covers the terrace floor suggesting a continuity between the inside and the outside space also.

The second floor accommodates two bedrooms on either side of the void and two bathrooms at the back right corner of the plan, (illustration 4. 3c). The former are visually linked through the glazed surfaces of the void, (illustration 4. 4). Each of them opens to a triangular balcony that overlooks the terrace below. Light coming through the loggia, the void and the skylight unites these spaces into a single system. This system allows horizontal and vertical links that reaching the extreme edges of the house create a continuity between the inside and the outside space.

- **DESCRIPTION OF STAGES**

It has been already mentioned that the first stage of this analysis is the last stage of the Volumetric Analysis. A brief description of this stage is given again with a view to connect the two analytical chapters. At stage one the shape describing all floor plans is a planar U. (TBH1 4.1, fig. 1, 4, 7, p. 239). Analysis pointed out that the geometrical centres of the block, the void, the column and the curvilinear space at the back are covered by the same back to front axis. The geometrical grids are also symmetrical on the back to front axis, (BF axis), and tripartite on the central geometrical bay, (TBH1 4.2, fig. 1, 4, 7, p. 239).

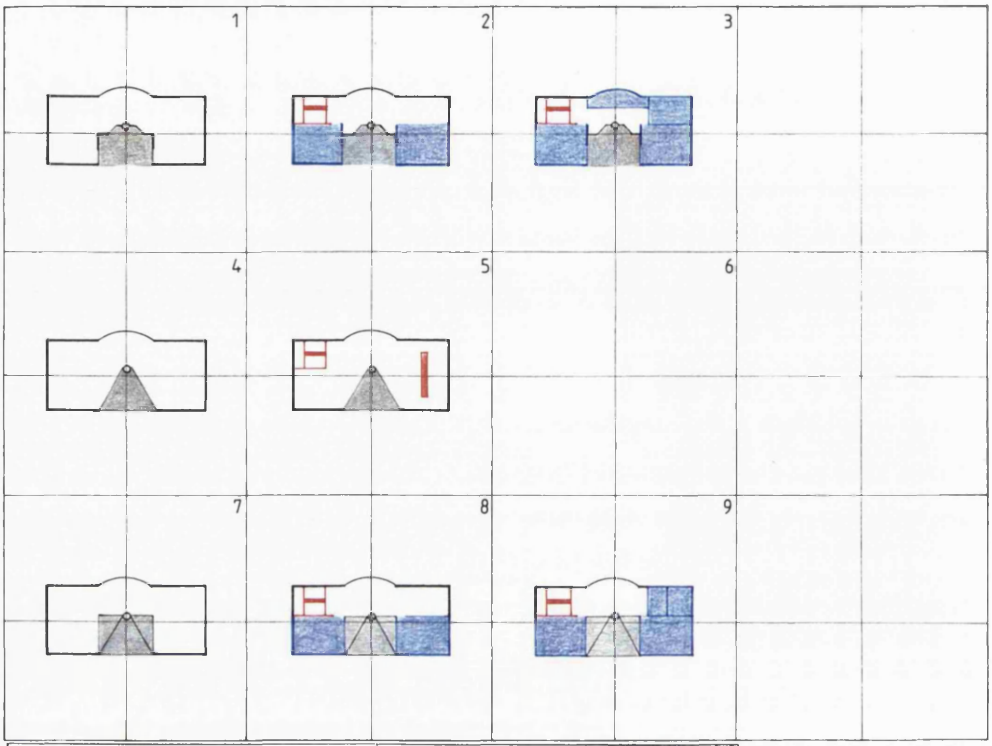
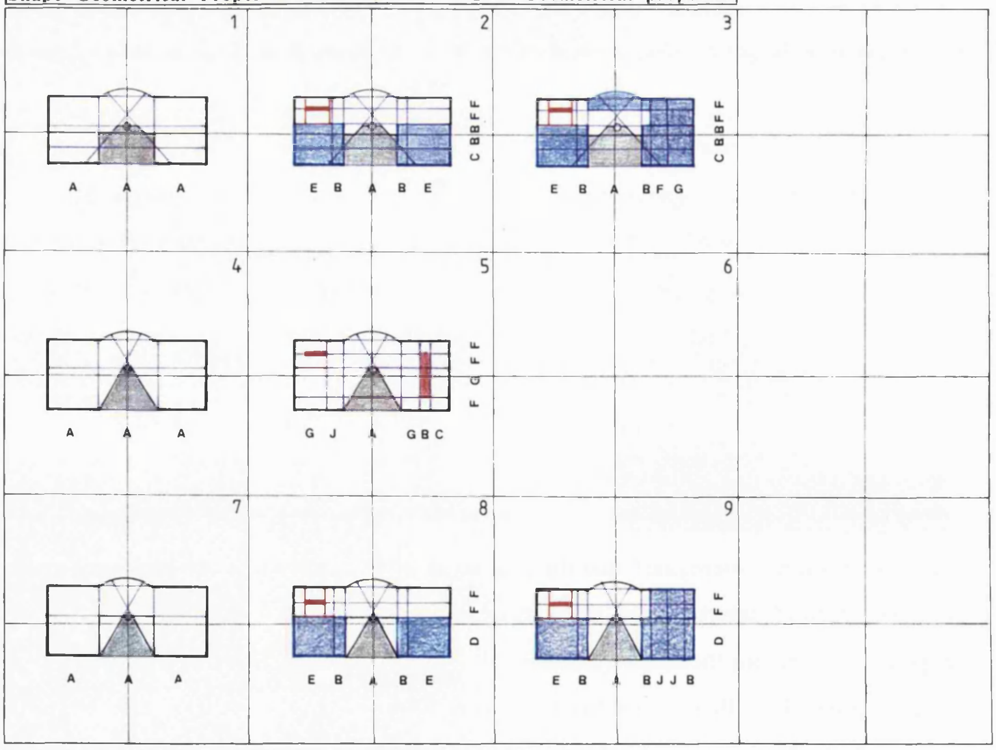



**Table BH1 4.1** Shape Geometrical Properties

**Table BH1 4.2** Grid Geometrical properties



At stage two the staircase is added in all floor plans, (TBH1 4.1, fig. 2, 5, 8). Two rectangles are superimposed at the front left and right corners of the ground and second floor, (TBH1 4.1, fig. 2, 8). The defining surfaces of these shapes coincide with the surfaces of the block and the void, Finally, a free standing partition is added at the right side of the first floor, (TBH1 4.1, fig. 5).

At the ground and second floor the two rectangles are symmetrical to each other with respect to the BF axis, (TBH1 4.1, fig. 2, 8). Thus, every shape apart from the staircase is symmetrical on this axis. Table 4.3, (p. 240), presents the ratio of symmetrical shapes on the BF axis to the total number of shapes. The Symmetry Shape index in these floors is 0.83 and 0.87 respectively. Therefore, there is 'just about' symmetry characterising the shape organisation.

The geometrical bays of the ground floor are arranged at length as following: E B A B E, (TBH1 4.2, fig. 2). Symmetry and tripartition govern the grid along this direction. From back to front the geometrical bays progress according to a F F B B C rhythm. This is not a symmetrical and tripartite pattern. This is reaffirmed by TBH1 4.4, LR, (p. 240), which presents the ratio of symmetrical lines with respect to the LR axis to the total number of lines, (Symmetry Line index, LR). This ratio is 0.22 at the ground floor, 0.25 at the first floor and 0.28 at the second floor.

At the first floor the geometrical centres of the staircase and the free standing partition are not covered by any of the axes of the block, (TBH1 4.1, fig. 5). Thus, there is no overall symmetry characterising the shape properties of this floor.

The grid bays are arranged at length according to the sequence: G J A G B C, (TBH1 4.2, fig. 5). This is not a symmetrical and tripartite pattern. However, the Symmetry Grid index is 0.70, (TBH1 4.4, p. 240). Thus, the organisation of the grid bays at length is 'just about' symmetrical and tripartite. At width they progress as following: F F G F. There is no symmetrical and tripartite organisation in this direction[5].

The geometrical bays at the second floor progress at length according to a E B A B E, rhythm, (TBH1 4.2, fig. 8). This arrangement is both symmetrical and tripartite. At width the progression of the grid bays is as following: F F D. There is no symmetry and tripartition in this organisation.

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5 The letters describing the rhythms of the grid bays provide a certain way to identify symmetry and tripartition. However, in certain cases minor discrepancies from these rules generate arrangements that are 'just about' symmetrical and tripartite. In these cases analysis refers to tables presenting the Symmetry Grid index to demonstrate the slight deviations from the canons regardless of the breaks in the rhythms of the letters. If no reference is made then the pattern is not characterised by 'just about' symmetry and tripartition.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.83 | 0.62 |
| 1ST | 1 | 0.66 | 0.66 |
| 2ND | 1 | 0.87 | 0.70 |

**Table BH1 4.3** - SYMMETRY SHAPE INDEX, (BF) - No of shapes sym on the BF axis/Total No of shapes

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 0.90 |
| 1ST | 1 | 0.70 | 0.70 |
| 2ND | 1 | 1 | 0.81 |

**Table BH1 4.4** - SYMMETRY GRID INDEX, (BF) - No of grid lines sym on the BF axis/Total No of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.25 | 0.22 | 0.22 |
| 1ST | 0.33 | 0.25 | 0.25 |
| 2ND | 0.33 | 0.28 | 0.28 |

**Table BH1 4.4 LR** - SYMMETRY GRID INDEX (LR) - No of grid lines sym on the LR axis/Total No of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.69 | 0.53 |
| 1ST | | 0.12 | 0.12 |
| 2ND | | 0.70 | 0.58 |

**Table BH1 4.5** - INSIDE/OUTSIDE LINE INDEX - No of geom lines of the internal and external elements/Total no of lines

At the ground floor nine out of thirteen lines, (9/13), generated by the extensions of the surfaces defining the elements of the interior coincide with the extensions of surfaces defining the elements of the external articulation. This ratio is defined as: *I/0 Line index,* (TBH1 4.5). This index at the ground floor is 0.69, (TBH1 4.5). At the first and second floor it is 0.12 and 0.70 correspondingly. Thus, at the ground and second floor the majority of the grid lines participate in both the internal and the external articulation. At the first floor different lines are used creating a sharp distinction between the former and the latter.

At stage three a curvilinear and a rectangular shape are superimposed at the back of the ground floor, (TBH1 4.1, fig. 3, p. 239). These shapes share their outer surfaces with the surfaces of the block. At the second floor two spatial rectangles are superimposed at the back right corner of the plan, (TBH1 4.1, fig. 9, p. 239). The outer surfaces of these shapes also coincide with the surfaces of the block. The first floor remains as it is described at stage two, (TBH1 4.1, fig. 5, p. 239).

The geometrical centres of the new rectangles at the ground floor are not covered by any of the axes of the block or the axes of any other element, (TBH1 4.1, fig. 3, p. 239). There is no overall pattern of symmetry governing the disposition of shapes.

However, a subtle balance is created between the staircase and the rectangle superimposed at the back right corner of the plans. This is based on a contrast between their asymmetrical appearance and their symmetrical positions with respect to the BF axis. Although an application of symmetry that covers all the parameters of shape definition is not achieved, the parameter of shape position preserves overall symmetry.

At the ground floor the geometrical grid progresses at length according to the sequence: E B A B F G, (TBH1 4.2, fig. 3, p. 239). This is not a symmetrical and tripartite pattern. However, the Symmetry Grid index is 0.90, (TBH1 4.4). Thus, the organisation of the grid bays is 'just about' symmetrical and tripartite. There are no changes introduced to the grid at width.

At the second floor there is no overall shape symmetry governing the disposition of shapes, (TBH1 4.1, fig. 9, p. 239). However, the Symmetry Shape index, (0.70), shows that the arrangement of the shapes on this plan is characterised by 'just about' symmetry, (TBH1 4.3).

Besides, if the rectangles at the back right corner of the layout are merged into a single shape then this is symmetrical in terms of position to the staircase on the other side of the plan. Similarly to the ground floor, there is a contrast between symmetry in terms of position and asymmetry in terms of shape appearance.

The grid is organised according to a E B A B J J B sequence at length and a F F D sequence at width, (TBH1 4.2, fig. 9, p. 239). There is no overall symmetry and tripartition governing the shape and grid properties in both directions. However, the Symmetry Grid index is 0.81, (TBH1 4.4, p. 240). The organisation of the grid bays at this stage is 'just about' symmetrical and tripartite on the BF axis and the central geometrical bay.

The I/O Line index at the ground floor is 0.53, (TBH1 4.5, p. 240). At the first floor it remains as defined at stage two, i.e. 0.12. Finally, at the second floor this index is 0.58.

- **COMPARISON ACROSS STAGES**

- **Physical properties**

At stage one the outside space at the ground floor is defined by both glazed and solid material, (TBH1 4.1, fig. 1, p. 239). The difference in the material defining this element is expressed by a difference in the thickness of the lines representing its contour. A variation in the thickness of these lines interrupts the uniformity of this contour[6].

It also creates a distinction between the block, the U and the outside space. This is because the block is defined by opaque surfaces, whereas the rest of the elements are defined by both opaque and transparent ones. This distinction enables the outer surfaces to group themselves towards the largest volumetric rectangle. In this way, the block retains its physical identity and its differentiation from the rest of the elements.

At the first and the second floor opaque surfaces define the block, while transparent ones define the void, (TBH1 4.1, fig. 4, 7, p. 239). On the other hand, the U is defined by both opaque and transparent material. In this way, the opaque surfaces complete the contour of the block preserving its hierarchical distinction from the U and the void.

At stage two the surfaces of the superimposed rectangles at the ground and second floor coincide with the surfaces of the block and the outside space, (TBH1 4.1, fig. 2, 8, p. 239). The physical definition of shapes by the same elements affects their recognisability as distinct components. However, the corners of these rectangles are either defined by both opaque and transparent surfaces or they lack complete physical

6 Analysis discusses the opaque/glazed surface distinction to give an account of how it affects the recognisability of the volume prior to the introduction of the internal elements. However, it is not suggested that design decisions about materials are necessarily taken prior to the internal ordering. This is something that the comparative analysis of stages will examine, i.e. the degree to which the material definition of the volume is determined by rules of the external, the internal or both the external and the internal articulation.

definition[7]. The differentiation of material along their contour transforms them into an interaction of volumetric and planar elements[8].

Thus, the contour of the block is uniform, whereas the contour of the rectangles is not. Every corner of the former provides with volumetric readings, whereas two of the corners of the latter provide with planar readings. These distinctions preserve the physical identity and the hierarchical distinction of the block from the rest of the shapes. Finally, at the first floor a lack of coincidence between the inner and the outer surfaces does not affect the physical coherence of the largest volume[9], (TBH1 4.1, fig. 5, p. 239).

At stage three the surfaces of the superimposed shapes at the ground and second floor coincide with the outer surfaces, (TBH1 4.1, fig. 3, 9, p. 239). These shapes are defined by both thin and thick lines[10]. Besides, some of their corners lack full physical definition. These characteristics maintain the differentiation between the block and the superimposed shapes resolving the conflict arising from the simultaneous participation of boundaries into large and small scale groupings.

To summarise, from stage one to stage three a gradual superimposition of shapes onto the initial rectangle multiplies the distribution of its surfaces into different shape descriptions. The complementary readings resulting from this multiplication are resolved by the distribution of material along the contour of the elements of a smaller scale. A classification of shapes into distinct categories is created preserving the physical identity of the largest scale component.

- **Geometrical properties.**

The organisation of shapes at the ground floor moves from overall symmetry at stage one to 'just about' symmetry at stage two, and asymmetry at stage three, (TBH1 4.1, fig. 1-3, p. 239, TBH1 4.3, p. 240). However, asymmetry characterises only the back of the layout. The front part retains symmetry throughout the stages, (TBH1 4.1, fig. 1-3, p. 239). Besides, analysis showed that a subtle balance is

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7 This is because a door entry is placed at this location.

8 Although shapes are discussed in terms of their two dimensional properties in plan, they also read as horizontal sections through volumes. Thus, describing a shape as an interaction of volumetric and planar components does not mean that description moves to the third dimension. It means that certain parts of this shape maintain its property to suggest a volume, whereas others do not. Shapes provide volumetric readings when all their corners are defined by solid or uniform material. On the other hand, they provide with both volumetric and planar readings when two different types of material are combined to define their corners.

9 The only exception is the staircase the surrounding surfaces of which coincide with the surfaces of the block. Nevertheless, this is not a closed and clearly distinguishable shape. Thus, its surfaces register towards the formation of the block.

10 In this case the distinction of line thickness represents a distinction between wall thickness and wall material rather than a distinction between opaque and glazed surface.

established at the back of the composition based on a contrast between asymmetrical shapes and their symmetrical positions on the plan. This balance together with the symmetrical organisation at the front of the plan reinforce the co-ordinating role of the BF axis.

At the second floor the organisation of shapes moves from symmetry to 'just about' symmetry, (TBH1 4.1, fig. 6-9, p. 239, TBH1 4.3, p. 240). Thus, the shape properties of the interior in these floors are close approximations of the shape properties of the exterior.

At the first floor the organisation of shapes changes from overall symmetry at stage one to asymmetry in the following stages, (TBH1 4.1, fig. 4-6, p. 239). Nevertheless, a strong intensification of the contour of the block by the means of thick surfaces creates an intensification of its geometrical properties. In this respect, although overall symmetry does not govern this layout, the physical distinction of the block from the rest of the elements strengthens the BF axis.

The geometrical grids in all floors move from symmetry and tripartition on the BF axis at stage one to 'just about' symmetry and tripartition in the following stages, (TBH1 4.2, fig. 1-9, p. 239, TBH1 4.4, p. 240). Therefore, the grid properties of the interior are close approximations of those of the exterior.

At width there is no overall symmetry and tripartition governing the organisation of the grids in any stage, (TBH1 4.4, LR, p. 240). Analysis carried out in the previous chapter identified a distinction between the BF and the LR axis. This distinction, it was argued, is based on the property of the former to co-ordinate a larger number of elements than the latter. This analysis identifies a similar distinction expressed by 'just about' symmetry on one axis and asymmetry on the other.

Looking at the relationship between the shape and the grid properties it turns out that at the ground and second floor at stage two the 'just about' symmetrical and tripartite organisation of shapes are close approximations of the symmetrical organisation of grid lines, (Symmetry Shape index: 0.83, 0.87, TBH1 4.3, p. 240, Symmetry Grid index: 1, TBH1 4.4, p. 240).

At stage three it is only at the second floor that this approximation takes place, (Symmetry Shape index: 0.70, TBH1 4.3, p. 240, Symmetry Grid index: 0.81, TBH1 4.4, p. 240). In the rest of the floors the obvious symmetries of the shape arrangement are replaced by subtler symmetries of the grids lines. However, even in these layouts the shape organisation approximates 'just about' symmetry approximating the 'just about' symmetrical organisation of the grids also, (Symmetry Shape Index: 0.62, 0.66, TBH1 4.3, p. 240, Symmetry Grid Index: 0.90, 0.70, TBH1 4.4, p. 240). Thus, there seems to be a tendency to create a coincidence between the two levels of properties in all floors.

The majority of the lines defining the superimposed elements at the ground and second floor at stage two coincide with the lines defining the elements of the volumetric articulation, (I/O Line index: 0.69, 0.70

respectively, TBH1 4.5, p. 240). At stage three the I/O Line index at the ground floor drops from 0.69 to 0.53 at three. At the second floor it moves to 0.58. The first floor has the lowest I/O Line index, (0.12).

The coincidence between a large number of lines of the internal organisation with those of the external organisation suggests that rules are applied from the latter to the former dictating the positions of elements on the plan. The decrease of the I/O Line index at stage three shows that it is only the elements of the small scale articulation that differentiate themselves from those of the large scale.

To recapitulate, the comparative examination of stages showed that the properties of the interior in each stage become close approximations of the properties of the exterior. There is a systematic tendency to subordinate all levels of articulation under the physical and geometrical rules of the largest volumetric component.

However, a tension between the simultaneous application and negation of symmetry is created based on deviations from symmetry introduced at the last stage. These deviations characterise the small scale articulation. As such, they cannot undermine the overall effect of symmetry operating in the large scale. On the contrary, they seem to reinforce the overall pattern by providing its formal opposite.

## • COMPARISON ACROSS BOTTA'S HOUSES

In this section the analysis moves to a comparative examination of Botta's houses. The aim is to answer the questions addressed at the beginning of this chapter, i.e. *How the formal properties of the two dimensional organisation of the interior of these houses become intelligible? How they interact with the three dimensional formal organisation structuring intelligibility of the houses as wholes?*

This examination raises the following questions:

- Is there a consistent pattern governing the transformation of the interior from one stage to the other?
- Which are the rules that remain invariant in the transformation?

## • THE PATTERNS OF THE TRANSFORMATION PROCESS

### • Operations and their order of occurrence

At stage one the majority of the floors are described by a simple shape. This is either a planar U, (BH1 4.1, fig. 1, 4, 7, p. 254, BH2 4.1, fig. 4, p. 255), or a planar U from one or two sides of which a component is subtracted to define a terrace, (BH2 4.1, fig, 7, p. 255, BH3 4.1, fig. 7, p. 256), or a planar L, (BH3 4.1, fig. 1, 4, p. 256), or a circle from the front and back sides of which one or two components are removed, (BH4 4.1, fig. 1, 4, 7, p. 257).

This shape is transformed through the operations of superimposition, addition and planar extension. The occurrence of these operations in relation to the analytic stages is presented in tables BH1-S, BH1-A/E, BH2-S, BH2-A/E, TBH3-S, BH3-A/E, TBH4-S, BH4-A/E. According to these tables superimposition occurs at both stages two and three throughout the houses[11].

Addition and planar extension occur mainly at stage two. At stage three eight out of twelve floors, (8/12), are not transformed by these operations. The only exceptions are the first floor of BH2 (TBH2, 4.1, fig. 6, p. 255), the second floor of BH3, (TBH3 4.1, fig. 9, p. 256) and the first and second floor of BH4, (TBH4 4.1, fig. 6, 9, p. 257).

Thus, there seems to be a consistent pattern associating superimposition with stages two and three and addition and extension mainly with stage two. *This shows that Botta employs a certain pattern of transformation during the design process.*

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11 It is only at the first floor of BH1 and BH4 that superimposition does not take place in any stage, (TBH1, fig. 4, 5, p. 254, TBH4, 4, 5, 6, p. 257).

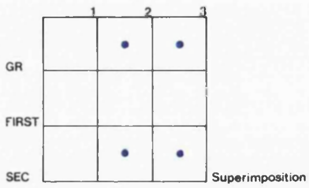


Table BH1—S

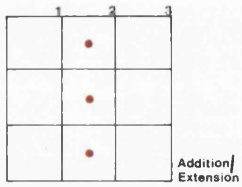
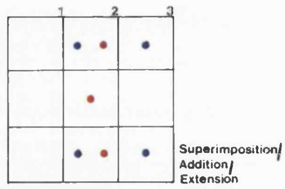


Table BH1—A/E



Table—S/A/E

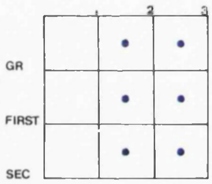


Table BH2—S

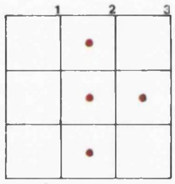


Table BH2—A/E

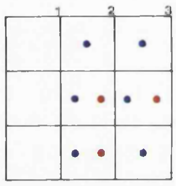


Table BH2—S/A/E

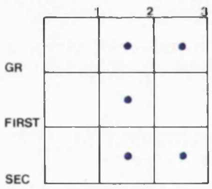


Table BH3—S

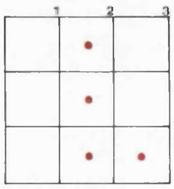


Table BH3—A/E

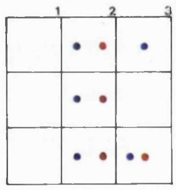


Table BH3/A/E

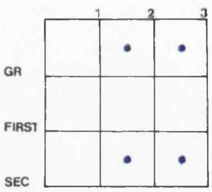


Table BH4—S

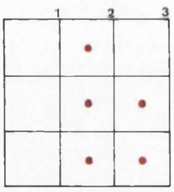


Table BH4—A/E

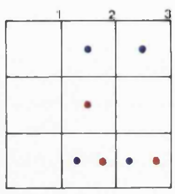


Table BH4—S/A/E

- **THE RELATIONAL LOGIC OF TRANSFORMATIONS**

- **Types of shapes - types of combinations**
- **Superimposition**

Superimposition at stage two attaches two shapes on either side of the void at the ground floor of BH1 and BH3, (TBH1 4.1, fig. 2, p. 254, TBH3 4.1, fig. 2, 256) and the second floor of BH2, (TBH2 4.1, fig. 8, p. 255). It also introduces two shapes at the left side of the first floor of BH2, (TBH2 4.1, fig. 5, p. 255), and three shapes at the left side of the second floor of BH4, (TBH4 5.1, fig. 8, p. 257). Finally, it attaches a shape at the centre of the ground floor of BH4, (TBH4 4.1, fig. 2, p. 257).

At the last stage this operation continuous attaching two shapes either at the back left and right side of the plan, (ground and first floor of BH2, ground and second floor of BH3, TBH2 4.1, fig. 3, 9, p. 255, TBH3 4.1, fig. 3, 9, p. 256), or at the back left or the back right side of it, (ground and second floor of BH1, ground floor of BH4, TBH1 4.1, fig. 3, 9, p. 254, TBH4 4.1, fig. 3, p. 257).

- **Addition and planar extension**

Extension at stage two extends the surfaces of the semi-cylindrical volume at the back of the houses towards the interior[12], (TBH2 4.1, fig. 2, p. 255, TBH3 4.1, fig. 2, p. 256, TBH4 4.1, fig. 2, p. 257). Thus, a vertical shaft is defined running from the bottom to the top of the houses.

Addition introduces a free standing element at the first floor of BH1, (TBH1 4.1, fig. 5, p. 254), and the second floor of BH3, (TBH3 4.1, fig. 8, p. 256), as well as a floor opening at the second floor of BH4, (TBH4 4.1, fig. 8, p. 257).

At stage three addition subdivides the floor area into sub areas through the introduction of thick partitions either at the left, (second floor of BH3, TBH3 4.1, fig. 9, p. 256), or at the right, (first floor of BH1, second floor of BH4, TBH1 4.1, fig. 5, p. 254, TBH4 4.1, fig. 9, p. 257), or at both the left and right sides of the plan, (first floor of BH4, TBH4 4.1, fig. 6, p. 257).

To summarise, the transformation process starts by extending the curved surfaces of the drum in all floors. It also superimposes two shapes either at the front left and right side of the ground and second floor or at the centre of the ground floor and the left side of the second floor. At the final stage it subdivides the floor plans by the addition of a rectangular partition. It also superimposes two volumetric components at the back left and right side of the ground and second floor plan or at the back right side of the ground floor plan.

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12 It is only in BH1 that there is no extension of the surfaces of the curvilinear element towards the interior of the house, (TBH1 4.1 fig. 2, 5, 8, p. 254). A planar element extending throughout the height of the building is added instead.

The superimposed shapes are either rectangles or planar Ls. Those on the sides of the void are defined by the surfaces of the block and the void. The ones on the sides of the drum are also defined by the outer surfaces of the block and the extended surfaces of the drum.

*Thus, there is not only an association between certain stages and certain operations but also between certain stages, certain shapes, certain combinations and certain locations that these shapes occupy on the plan.*

- **RULES OF COMBINATIONS**

- **Physical properties**

Volumetric Analysis looked at the degree of explicit/implicit physical definition of the volumes as a factor influencing the physical identity of the block and the constituents into which this is analysed. Analysis of the interior focuses on the physical presence of shapes as well as on the ways this is articulated through the type of material used. Thus, it looks at the ways distinctions between opaque and transparent, thick and thin walls articulate the physical relations amongst the large and the small scale components.

At stage one the distribution of material gives solid definition to the block and solid and transparent definition to the U and the void, (TBH1 4.1, fig. 1, 4, 7, p. 254, TBH2 4.1, fig. 1, 4, 7, p. 255, TBH3 4.1, fig. 1, 4, 7, p. 256, TBH4 4.1, fig. 1, 4, 7, p. 257). A classification of elements into different shape categories is achieved assigning volumetric readings to the block and volumetric and planar readings to the other components.

At stage two the extended surfaces of the drum interrupt the continuity of the outer surfaces, (TBH2 4.1, fig. 2, 5, 8, p. 255, TBH3 4.1, fig. 2, 5, 8, p. 256, TBH4 4.1, fig. 2, 5, 8, p. 257)[13]. According to Arnheim when two shapes overlap the unit whose contour is interrupted completes itself behind the covering shape[14]. Thus, these surfaces can be inferred travelling behind the drum restoring the physical identity of the block.

At stages two and three a superimposition of elements that share their defining lines with the lines of the block increases the number of shapes defined by the outer surfaces. Simultaneous readings are created that

13 In BH4 the curvilinear element is inscribed in the perimeter of the cylinder., (TBH4 4.1, fig. 2, 5, 8, p. 257), Thus, the surfaces of the latter are not occluded by the extended surfaces of the former.

14 Rudolf Arnheim, 'Art and Visual Perception, A Psychology of the Creative Eye', University of California Press, Berkeley, Los Angeles, London, p. 248.

pull towards different directions disturbing the recognisability of the large rectangle, (TBH2 4.1, fig. 2, 3, 5, 6, 8, 9, p. 255, TBH3 4.1, fig. 2, 3, 5, 6, 8, 9, p. 256, TBH4 4.1, fig. 2, 3, 5, 6, 8, 9, p. 257).

However, this rectangle retains its physical definition by solid surfaces. On the other hand, the superimposed shapes are analysed into volumetric and planar components by a simultaneous definition of their corners by opaque and glazed surfaces. The conflicting readings are resolved re-establishing the priority of the block over the rest of the elements.

There are cases in which these readings are not resolved by the opaque/glazed distinction. Thus, at the ground and second floor of BH2 at stage three, (TBH2 4.1, fig. 3, 9, p. 255), the massive definition of the side facing corners of the superimposed elements at the back left and right corners disturb the continuity of the outer surfaces. The same ambiguous situation is produced at the ground floor of BH4 by the volumetric definition of the corners at the front of the cylinder, (TBH4 4.1, fig. 1, 2, 3, p. 257).

In these cases the geometrical co-ordination of the surfaces of the block on the BF and the LR axes restores the overall pattern. In Volumetric Analysis it was suggested that the extensive co-ordination of elements by these axes strengthens their organising role. It was also argued that the increased strength of the geometrical properties of a shape results in an increased strength of its physical identity. *Thus, the geometrical ordering of the configuration seems to reverse the effects of its physical ordering.*

Addition at stage two and three takes place inside the volumes in a way that the outer surfaces are not affected by the new elements, (TBH1 4.1, fig. 2, 3, 5, 6, 8, 9, p. 254, TBH2 4.1, fig. 2, 3, 5, 6, 8, 9, p. 255, BH3 4.1, fig. 2, 3, 5, 6, 8, 9, p. 256, BH4 4.1, fig. 2, 3, 5, 6, 8, 9, p. 257). Thus, the identity of the block is not influenced by the components introduced inside the volume.

- **PHYSICAL PROPERTIES AND INTELLIGIBILITY**

- **Intelligibility of the interior**

To summarise, the comparative analysis shows that in these houses there is a multiple distribution of the outer surfaces into large and small scale shape formations. However, there is a predominant distribution that enables these surfaces to extend beyond shape definitions of a small scale and complete the largest rectangle in all stages. The rules governing the physical and material articulation of the plan in process are subjected to the rules of the first stage. The block retains its recognisability throughout the stages. It could be argued that these plans are grasped as simple rectangles, or circles in the case of BH4, which enter into hierarchical relations with shapes of a less clear physical identity and of a less global significance.

- **Intelligibility of the houses as wholes**

Volumetric Analysis also observed a hierarchical application of rules from the largest to the smallest scale in the articulation of the volume. According to conventions established in the methodology section, the last stage of this analysis became the first stage of the analysis of the plan. Thus, there is a hierarchical application of rules from the volume to the plan and from the external to the internal articulation.

A single rule referring to the physical properties of the largest scale element directs the process of making of the houses as wholes. They seem to be intelligible as simple volumetric enclosures sculptured in the centre and accommodating individual spaces that are bent and subordinated by the formal requirements of the large scale.

- **GEOMETRICAL PROPERTIES**

At this stage the comparative description of houses moves to the geometrical properties. These are analysed in terms of the geometrical organisation of plans seen as shape configurations as well as as grid configurations generated by the extended lines by which shapes are defined.

- **Shape geometrical properties**

Starting with the shape properties a first cross examination shows that the transformation of the interior moves from overall or 'just about' shape symmetry at stage one to 'just about' symmetry at stage three in four out of twelve plans[15], (4/12), (TB 4.1, p. 258). Therefore, the articulation of the last stage does not preserve the properties of the first stage in the majority of the plans.

However, at stage two the ground and second floor of BH1 and BH2, the second floor of BH3 and all plans of BH4 are characterised by 'just about' symmetry, (seven out of twelve plans, 7/12), (TB 4.1, p. 258). Therefore, symmetry breaks by the small scale articulation occurring at the last stage. Deviations from symmetry generated by small scale elements do not generally undermine the effect of the overall pattern. *In this respect, the properties of the interior are closely associated to the properties of the exterior.*

A gathering of elements under the co-ordinating role of the BF axis is established extending from the organisation of the volume to the organisation of the plan. However, the small scale articulation deviating from the overall symmetrical pattern challenges the intensification of the axis. According to Gombrich any continuous pattern, i.e. any pattern that constantly exhibits the same organising principle, 'sinks below the threshold of attention'. On the other hand, discontinuities interrupting a continuous and regular course of action give the viewer a 'jolt'[16].

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15 These are: the second floor of BH1, the ground and second floor of BH2 and the first floor of BH4.

16 E. H. Gombrich, 'The Sense of Order, A Study in the Psychology of the Decorative Art', Phaidon Press Limited, 1984, p. 108.

In this context, the deviations from symmetry can be seen as interruptions in the consistent application of rules from outside-in and from the largest to the smallest element. They are discontinuities arousing curiosity and compelling the observer to scrutinise the plan in order to identify subtle distinctions.

It was suggested that such discontinuities also occur through an application of symmetry in terms of one shape characteristic and suspension of symmetry in terms of another characteristic. For example, there are cases in which shapes are symmetrical in terms of their position in relation to the BF axis and asymmetrical in terms of their size and proportions[17]. There are also cases in which shapes are symmetrical in terms of these parameters and asymmetrical in terms of their distance from the axis[18].

In a perfectly symmetrical situation elements register as identical concepts. They seem to direct attention to the axis that regulates their relation rather than to themselves. On the other hand, in an interrupted symmetry, in which small scale elements operate in accordance as well as independently of the overall pattern, their presence is highlighted.

Symmetry in relation to one shape characteristic and asymmetry in relation to another generates a conflict that is subtler than the one introduced by 'just about' symmetry. Whereas the latter directs attention to those shapes that break the overall pattern, the former highlights the subtleties and the complexities amongst the parameters that constitute a shape. However, both kinds of deviations gain their significance by reference to the overall pattern. The small scale articulation introduces a second system of attraction parallel to the BF axis, while at the same time increasing the effects of overall symmetry.

To summarise, every stage creates a close approximation between the shape properties of the interior and those of the exterior. This approximation increases the number of elements co-ordinated by the BF axis intensifying its organising role. The block and its geometrical principles are, thus, distinguished by their property to prevail in the configuration as a whole. The house registers as a single volume that is externally and internally centred around the BF axis.

Nevertheless, the local scale articulation, certain characteristics of which deviate from the overall canon increases the mental effort necessary to capture the organisation. Symmetry becomes strengthened through an accommodation of its formal opposite.

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17 An example of this case is given by the superimposed rectangles at the back right corner of the second floor of BH1, (TBH1 4.1, fig. 9, p. 254). These rectangles, seen as a single shape, are symmetrical to the staircase on the other side of the plan in terms of their distance from the BF axis, (TBH3 4.1, fig. 5, p. 256).

18 For example the superimposed rectangles on either side of the drum at the first floor of BH3 are symmetrical in terms of size and asymmetrical in terms of position in relation to the BF axis.

- **Grid geometrical properties**

The organisation of the grids at stage one is characterised by overall symmetry and tripartition in eight plans, (8/12), and 'just about' symmetry in four plans[19], (4/12), (TB 4.2, p. 258). At stage two there is overall symmetry organising six plans[20], (6/12) and 'just about' symmetry characterising four plans[21], (4/12). Finally, at stage three eight out of twelve plans are governed by 'just about' symmetry[22], (8/12).

Thus, the grid properties move from overall symmetry and tripartition on the BF axis and the central geometrical bay to 'just about' symmetry. Similarly to the properties of the shapes, the grid properties of the interior are associated to the properties of the external articulation. The majority of the new elements are controlled by the rules governing the organisation of the largest volumetric components.

At width it is only the grid of the ground floor of BH4 that remains symmetrical and tripartite with respect to the LR axis throughout the stages, (TB 4.2, LR, p. 258). Besides, the ground floor of BH3 is 'just about' symmetrical and tripartite at stage three, (TB 4.2, LR, p. 258). The rest of the floors are not governed by overall or 'just about' symmetry and tripartition in any stage. In this respect, this axis retains a less global significance in both the external and the internal organisation.

Similarly to the observations put forward in the examination of the shape properties, 'just about' symmetry is largely introduced at stage three by the small scale articulation occurring at this stage. At stage two there are still six out of twelve plans, (6/12), that are characterised by overall symmetry and tripartition. 'Just about' symmetry increases the degree of attention necessary to comprehend a pattern. Both the local and the global scale appear reinforced by the simultaneous application and negation of rules.

At the first and the second floor of BH2, the ground floor of BH3 and the ground and second floor of BH4 at stage three the I/O Line index is above 0.70, (TB 4.3, p. 259). Thus, the majority of the lines defining the elements of the interior coincide with the lines defining the elements of the exterior. In these cases rules are applied from the largest to the smaller components controlling not only the relations amongst the elements of the interior and those of the exterior but also the positions of the former on the plan.

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19 All floors of BH1 and BH2 and the ground and first floor of BH4.

20 These are: the ground and second floor of BH1, the ground and first floor of BH2 and BH4, (TB 4.2, p. 258).

21 The first floor of BH1, the second floor of BH2, the ground floor of BH3 and the second floor of BH4.

22 These are: all floors of BH1, the first and second floor of BH2 and the ground and first floor of BH4. Besides, the ground floor of BH2 is characterised by overall symmetry throughout the stages. If the ground floor of BH3 which approximates 'just about' symmetry is also taken into consideration then nine out of twelve plans are 'just about' symmetrical and tripartite.

At stage two there is a larger number of plans that have an I/O Line index higher than 0.70. These are the second floor of BH1, the first and second floor of BH2, the ground and second floor of BH3 and all floors of BH4. The decrease of the I/O line index at stage three indicates that it is only the lines defining the small scale elements that are placed independently of those of the large scale.

Coming to the relationship between the shape and the grid structure it turns out that at stage three symmetry or 'just about' symmetry characterises the organisation of both layers of properties in four plans, (4/12). These are the second floor of BH1, the ground and the second floor of BH2 and the first floor of BH4 (TB 4.1, TB 4.2, p. 258).

At the ground and first floor of BH1, the first floor of BH2 and the ground floor of BH4 the 'just about' symmetrical and tripartite organisation of the grid is contrasted with the lack of overall symmetry of the shape organisation, (TB 4.1, TB 4.2, p. 258). It has been suggested that a symmetrical disposition of shapes is visually more evident than a symmetrical organisation of grid lines. This is because shapes are physically identifiable elements manifesting their symmetry through a symmetrical distribution of their defining sides. In this respect, the plans mentioned above substitute the obvious symmetries of the shape organisation with less obvious regularities of the organising grids.

The lack of co-ordination between the two systems of properties weakens the strength of the overall pattern. However, at the ground and second floor of BH1 and BH2 and all floors of BH4, (seven out of twelve plans, 7/12), at stage two there is a co-ordination between the shape and grid organisation based on an overall or 'just about' symmetrical and tripartite organisation of both, (TB 4.1, TB 4.2, p. 258). Deviations from an one-to-one correspondence between the two layers of properties is undertaken by the elements of the small scale. In this respect, the overall pattern of co-ordinated symmetry retains its strength.

- **GEOMETRICAL PROPERTIES AND INTELLIGIBILITY**

A comparative description of geometrical properties of all houses shows that the properties of each stage are close approximations of those of the first stage. There is a constant intensification of the BF axis and the central geometrical bay achieved by a systematic gathering of shapes and grid lines under their co-ordinating role.

Analysis also shows that elements are placed on the plan following the constraints determined by the positions of the elements of the external articulation. The alignments amongst the surfaces of the exterior and those of the interior increase the number of physical elements arranged along a geometrical line. The more a geometrical line becomes physically defined the more observable is. *Thus, the co-ordination of the surfaces of the interior and the exterior by the same lines makes the grid visible and easily identifiable.*

Besides, this co-ordination retains the number of new lines introduced to the grid during the transformation of the interior as low as possible. Thus, the simplicity of the grid controlling the relations amongst the elements of the external articulation is retained. This eases also intelligibility allowing access to the overall pattern.

This systematic application of rules shows a tendency to preserve the properties of the first stage. In other words, it shows a tendency to preserve the properties of the volumetric articulation. Thus, the houses are understood as simple geometrical configurations in which a simple volumetric component and its geometrical axis play the dominant role.

The deviations from the overall canon of symmetry introduced by the small scale articulation act as local points of 'conflict' that rather reinforce than undermine the predominance of the overall pattern. Besides, they increase the attention necessary to capture the relationship between the large and the small scale articulation.

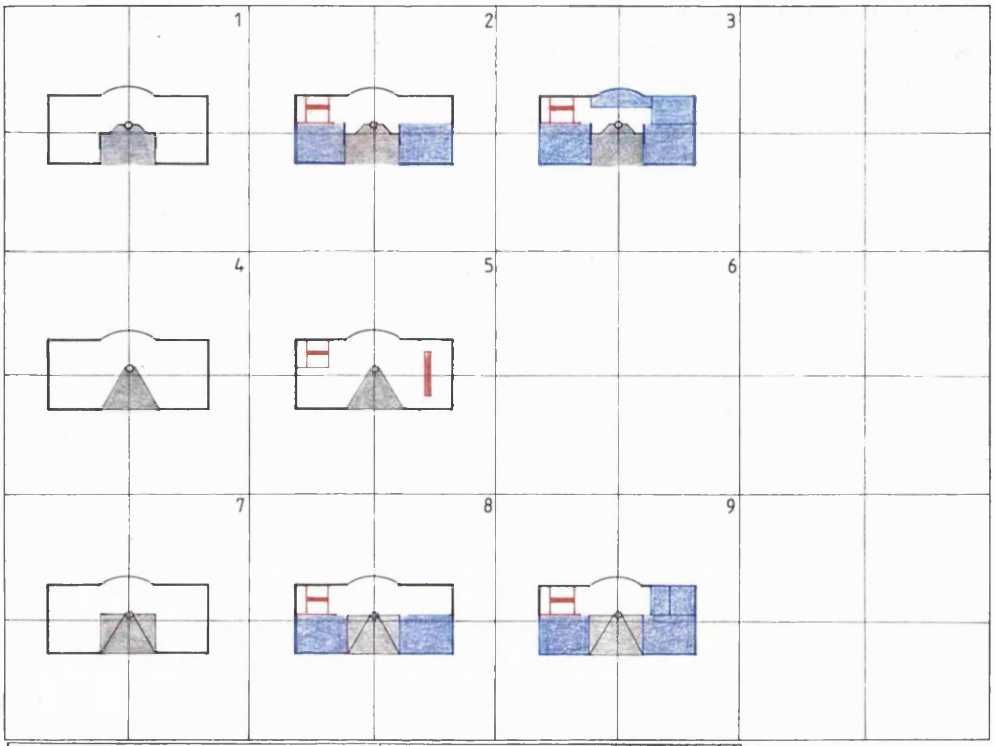
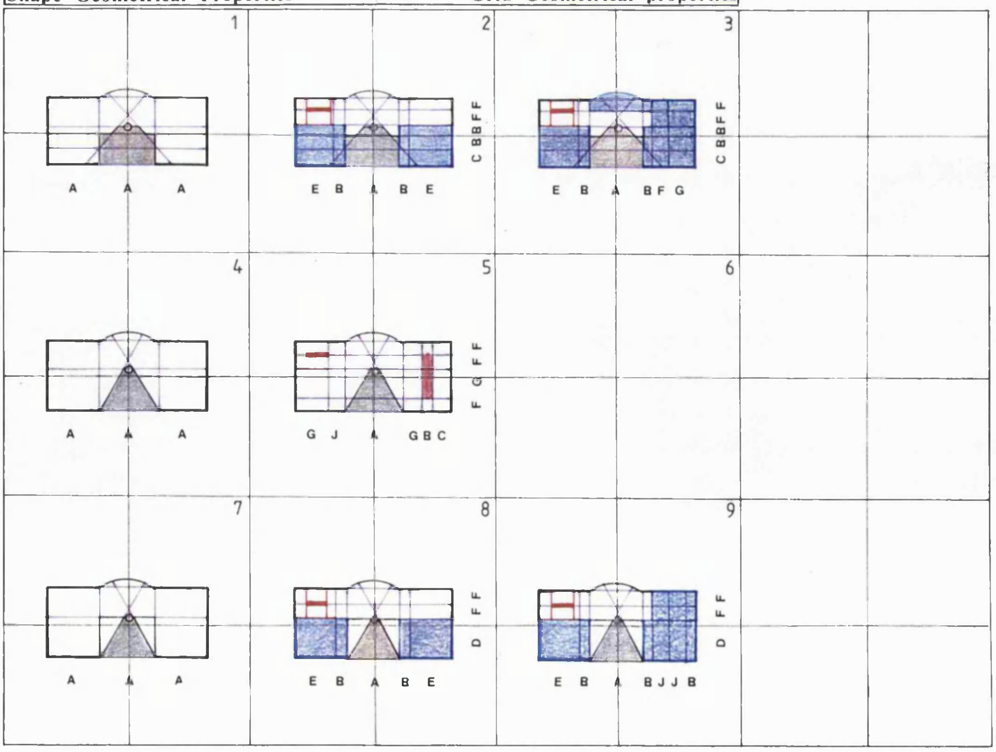



Table **BH1 4.1**
Shape Geometrical Properties

Table **BH1 4.2**
Grid Geometrical properties



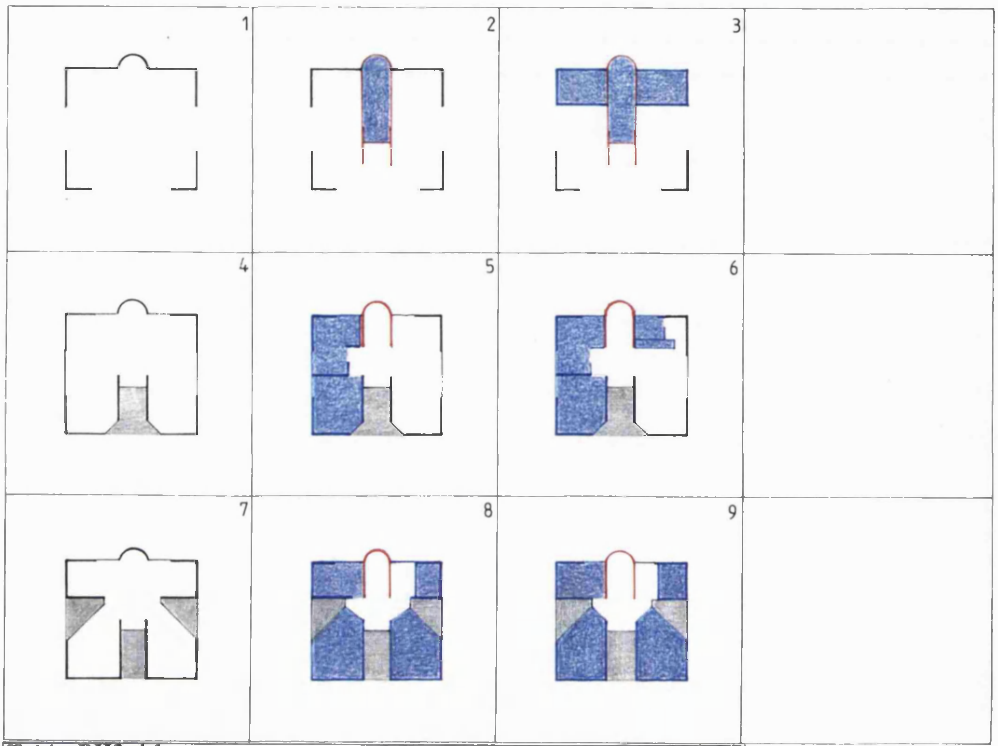
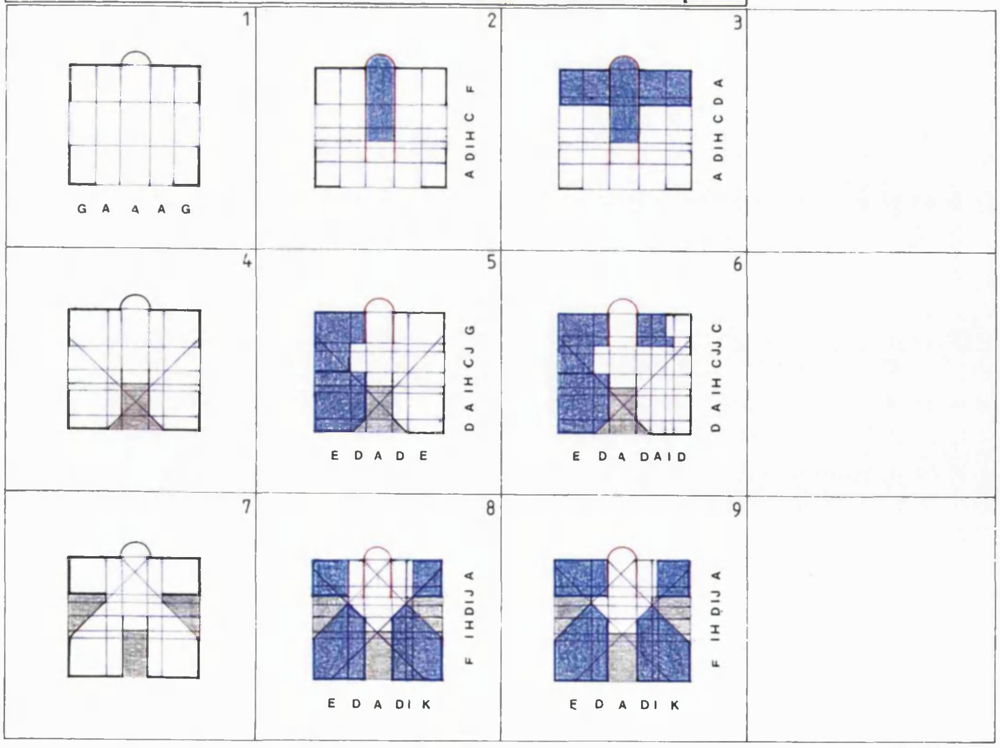



Table BH2 4.1
Shape Geometrical Properties

Table BH2 4.2
Grid Geometrical Properties



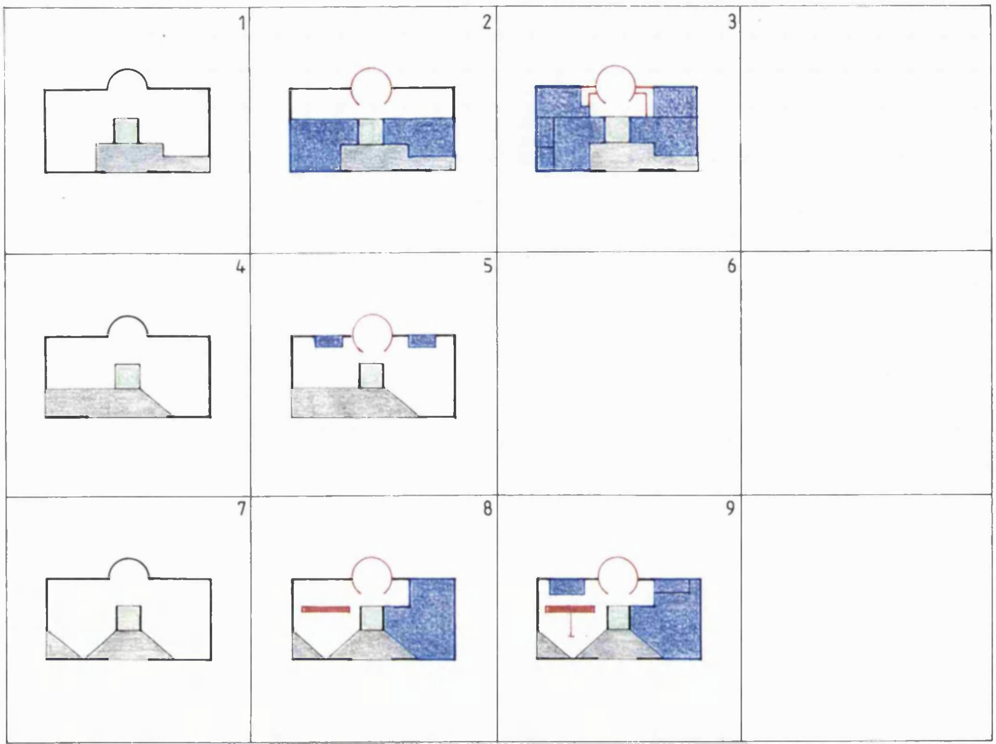
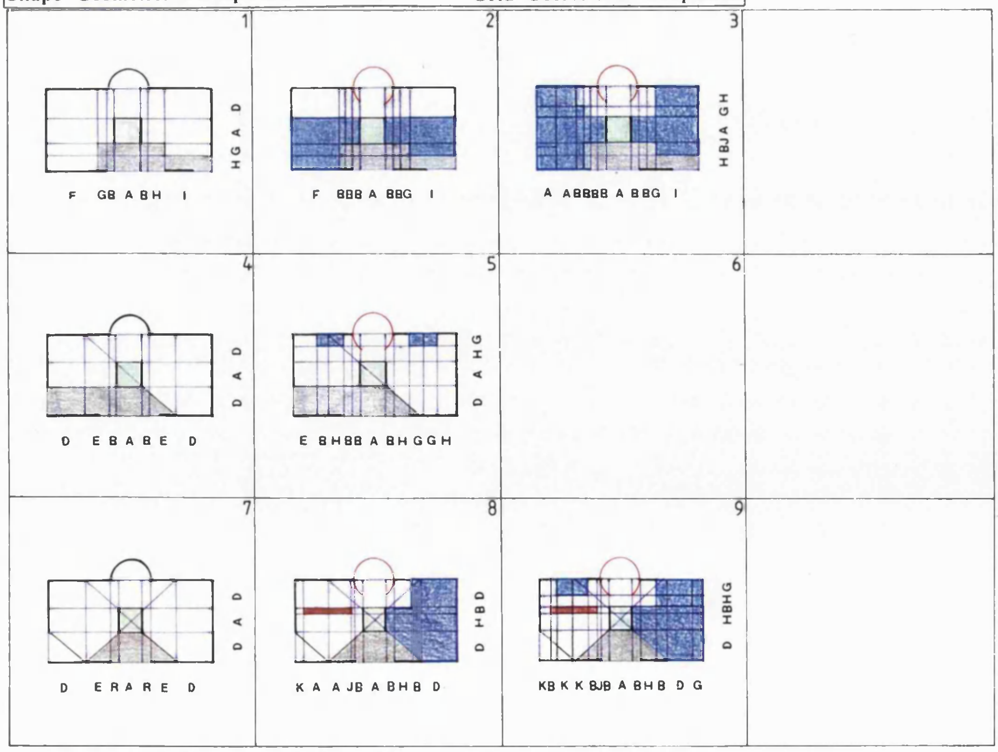



Table **BH3 4.1**
Shape Geometrical Properties

Table **BH3 4.2**
Grid Geometrical Properties



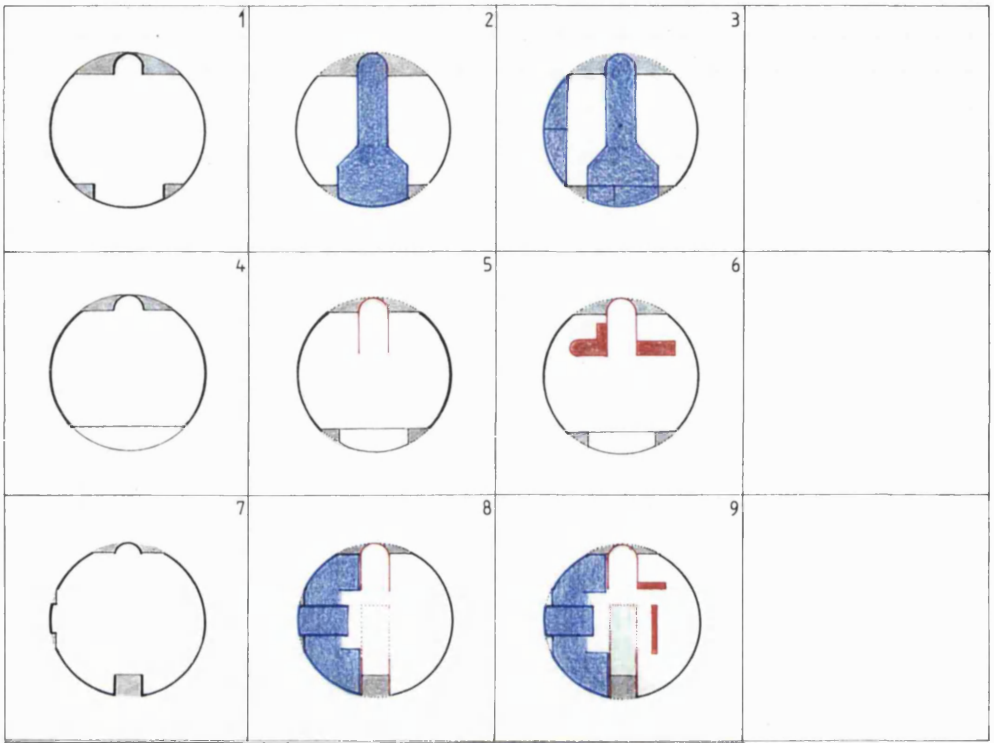
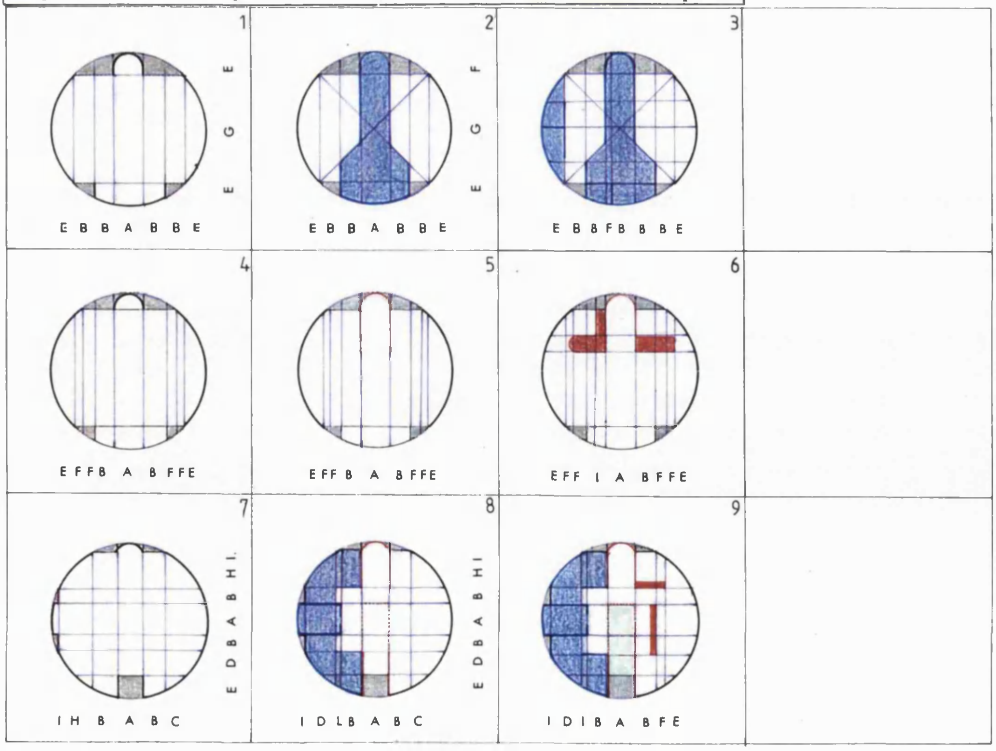



Table **BH4 4.1**
**Shape Geometrical Properties**

Table **BH4 4.2**
**Grid Geometrical Properties**



| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 1 | 0.83 | 0.62 | 1 | 1 | 1 | 0.75 | 0.50 | 0.30 | 1 | 1 | 0.66 |
| 1ST | 1 | 0.66 | 0.66 | 1 | 0.66 | 0.50 | 0.75 | 0.50 | 0.50 | 1 | 1 | 0.77 |
| 2ND | 1 | 0.87 | 0.70 | 1 | 0.88 | 0.88 | 0.80 | 0.57 | 0.40 | 0.71 | 0.72 | 0.61 |

Table B 4.1
**SYMMETRY SHAPE INDEX, (BF) - No of shapes sym on BF axis/Total no of shapes**

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 1 | 1 | 0.90 | 1 | 1 | 1 | 0.77 | 0.81 | 0.69 | 1 | 1 | 0.90 |
| 1ST | 1 | 0.70 | 0.70 | 1 | 1 | 0.81 | 0.90 | 0.35 | 0.35 | 1 | 1 | 0.90 |
| 2ND | 1 | 1 | 0.81 | 1 | 0.91 | 0.91 | 0.91 | 0.60 | 0.50 | 0.85 | 0.75 | 0.66 |

Table B 4.2
**SYMMETRY GRID INDEX, (BF) - No of geom lines sym on BF axis/Total no of lines**

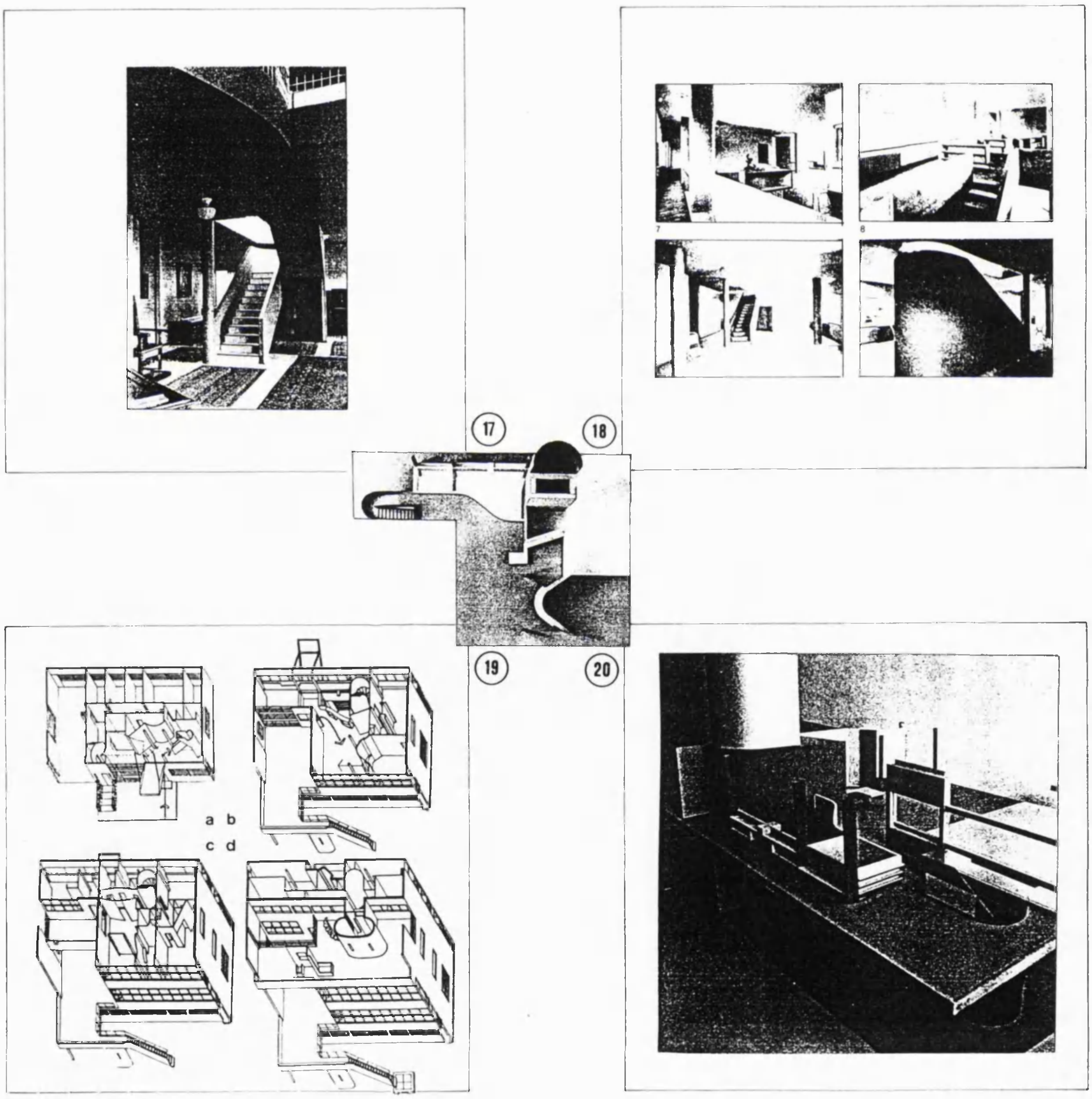
| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 0.25 | 0.22 | 0.22 | 0.20 | 0.62 | 0.55 | 0.66 | 0.66 | 0.75 | 0.75 | 0.83 | 0.88 |
| 1ST | 0.33 | 0.25 | 0.25 | 0.50 | 0.45 | 0.41 | 0.66 | 0.57 | 0.57 | 0.25 | 0.16 | 0.16 |
| 2ND | 0.33 | 0.28 | 0.28 | 0.50 | 0.38 | 0.38 | 0.50 | 0.66 | 0.60 | 0.62 | 0.62 | 0.62 |

Table B 4.2 LR
**SYMMETRY GRID INDEX, (LR) - No of geom lines sym on LR axis/ Total no of lines**

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | | 0.69 | 0.70 | | 0.20 | 0.45 | | 0.93 | 0.75 | | 1 | 0.85 |
| 1ST | | 0.12 | 0.12 | | 0.83 | 0.73 | | 0.54 | 0.54 | | 1 | 0.44 |
| 2ND | | 0.70 | 0.58 | | 0.70 | 0.70 | | 0.75 | 0.66 | | 0.83 | 0.84 |

Table B 4.3
**INSIDE/OUTSIDE LINE INDEX - No of geom lines of the internal and external elements/Total no of lines**

4



## L E C O R B U S I E R - V I L L A S T E I N - ( L H 1 )

- **GENERAL DESCRIPTION, (illustrations 4.17-4.20)**

Access to the house is through two entrances that are symmetrically located on the front facade, (illustration, 4.19a, p. 260). The one at the left leads to the garage and the service areas occupying the right and the back sides of the ground floor. The entrance at the right leads to an entry hall extending from the centre to the left side of the composition. Four columns inside this hall mark the axis of movement. A curved plane and an oblique surface at the end of this axis assert the entry and direct the visitor to a staircase placed on the lateral axis, (illustration 4.19a, p. 260).

Ascending the staircase the visitor reaches an L shaped living room, (illustration 4.19b, p. 260). The piano shaped opening at the floor divides this space into two areas connected by a narrow passage. A curvilinear volume at the right of the opening encloses a second staircase leading to the second and third floor.

The kitchen and dining areas are situated at the right side of the plan strictly enclosed within their defining surfaces. The left facing surface of the latter curves outwards protruding into the living room, (illustration 4.19b, 4.20, p. 260). Two columns symmetrically placed with respect to this surface accentuate its sculptural treatment.

The second floor houses three bedrooms with their service spaces, (illustration 4.19c, p. 260). Two bedrooms are placed at the wide part of the L shaped plan flanking a bathroom. The right surface of this bathroom is sculptured such as to accommodate a basin and to expose two columns inside the bedroom at the left side. The third bedroom is located at the extreme left side of the plan followed by a boudoir, a lingerie and a bathroom that extends at the back and the left side of the staircase. A corridor defined by curved surfaces connects these spaces together. Unlike the uninterrupted flow of space constructed at the first floor, spatial subdivision into separate rooms is the main organisational principle of this level.

The third level contains also rooms that are clearly enclosed by their defining surfaces, (illustration 4.19d, p. 260). A corridor facing the garden connects two bedrooms and a bathroom at the left with two bedrooms at the right side of the staircase. Finally, a study space is placed in the elliptical room that protrudes towards the terrace.

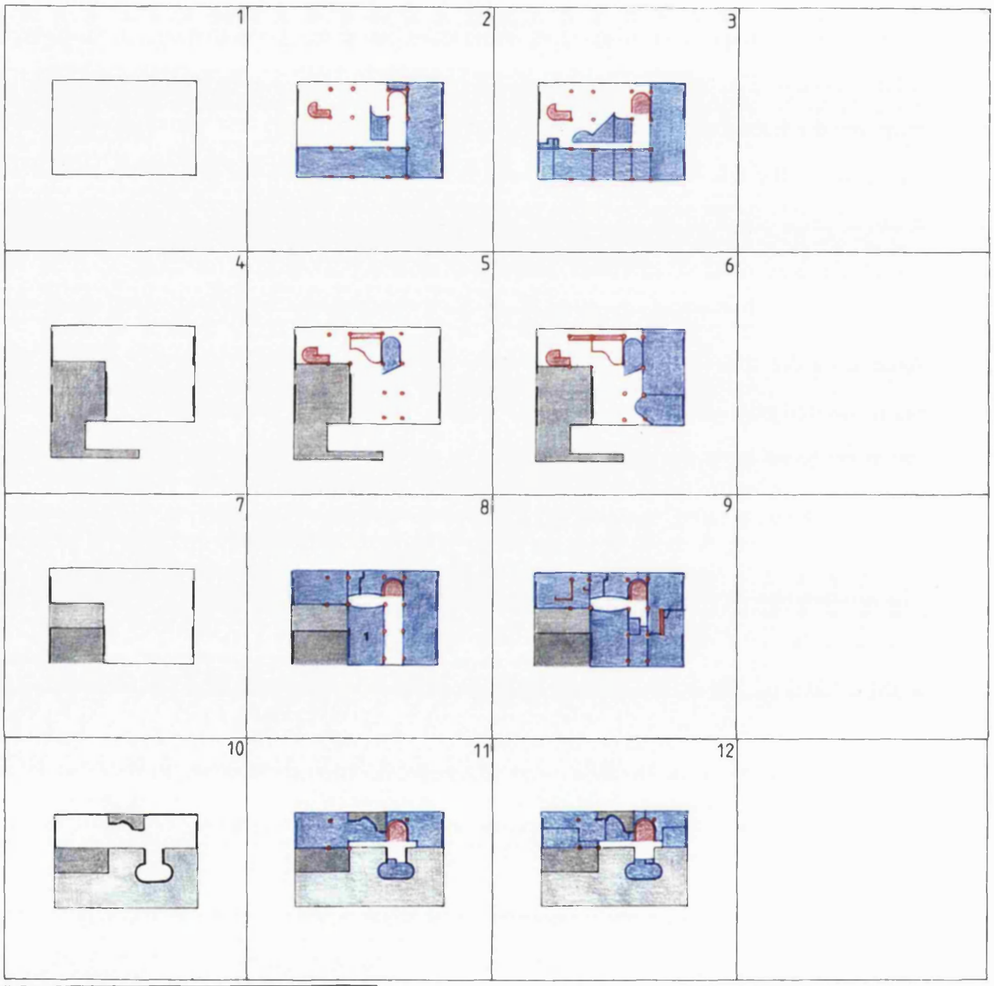



Table **LH1 4.1**
**Shape Geometrical Properties**

- **DESCRIPTION OF STAGES**

In Volumetric Analysis it was pointed out that at stage one the ground floor is characterised by overall shape symmetry with respect to the BF and the LR axes, (TLH1 4.1, fig. 1). It also suggested that the second floor is organised by grid symmetry and tripartition with respect to the BF axis, (TLH1 4.2, fig. 7, p. 263).

The distribution of glazed and opaque material along the side facing surfaces of the volumes introduces new lines to the grids. These lines extend from the left to the right side of the composition altering the grid organisation at width. Thus, at the ground floor the arrangement of the grid bays progresses as following: E A A A, (TLH1 4.1, fig. 1). At the first floor this arrangement is based on the following rhythm: E A H F A E, (TLH1 4.2, fig. 4, p. 263). At the second and third floor the sequences of the grid bays are E A A A E, (TLH1 4.2, fig. 7, p. 263), and E E F F E E A respectively, (TLH1 4.2, fig. 10, p. 263). Thus, it turns out that it is only at the second floor that the organisation of the grid is characterised by overall symmetry and tripartition.

At stage two the structural elements are introduced to all floor plans, (TLH1 4.1, fig. 2, 5, 8, 11). Two staircases are added at the ground floor. Besides, five volumetric rectangles are superimposed on this plan, (TLH1 4.1, fig. 2). Four of these rectangles are situated at the periphery of the composition sharing their surfaces with the outer surface of the volume.

The changes occurring at the first floor concern with the addition of a staircase at the left and the superimposition of another staircase at the right side of the layout, (TLH1 4.1, fig. 5). They also concern with the introduction of a piano shaped opening on the floor.

A staircase is added at the right side of the second and third floor. Besides, five shapes are superimposed on the second floor and three shapes are superimposed on the third floor, (TLH1 4.1, fig. 8, 11). These elements share their defining surfaces with the outer surfaces of the volume.

None of the geometrical centres of the superimposed components is located on the BF or on the LR axis in any floor[23], (TLH1 4.1, fig. 2, 5, 8, 11). At the ground floor the geometrical grid consists of five bays that progress from left to right as following: B B F F B, (TLH1 4.2, fig. 2, p. 263). There is no symmetry and tripartition governing the arrangement of the grid lines along this direction. At width the rhythm of the geometrical bays is as following: E G G F H A. There is no symmetry and tripartition along this direction either.

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23 The only exception is the superimposed rectangle at the right side of the second floor the geometrical centre of which lies on the LR axis.

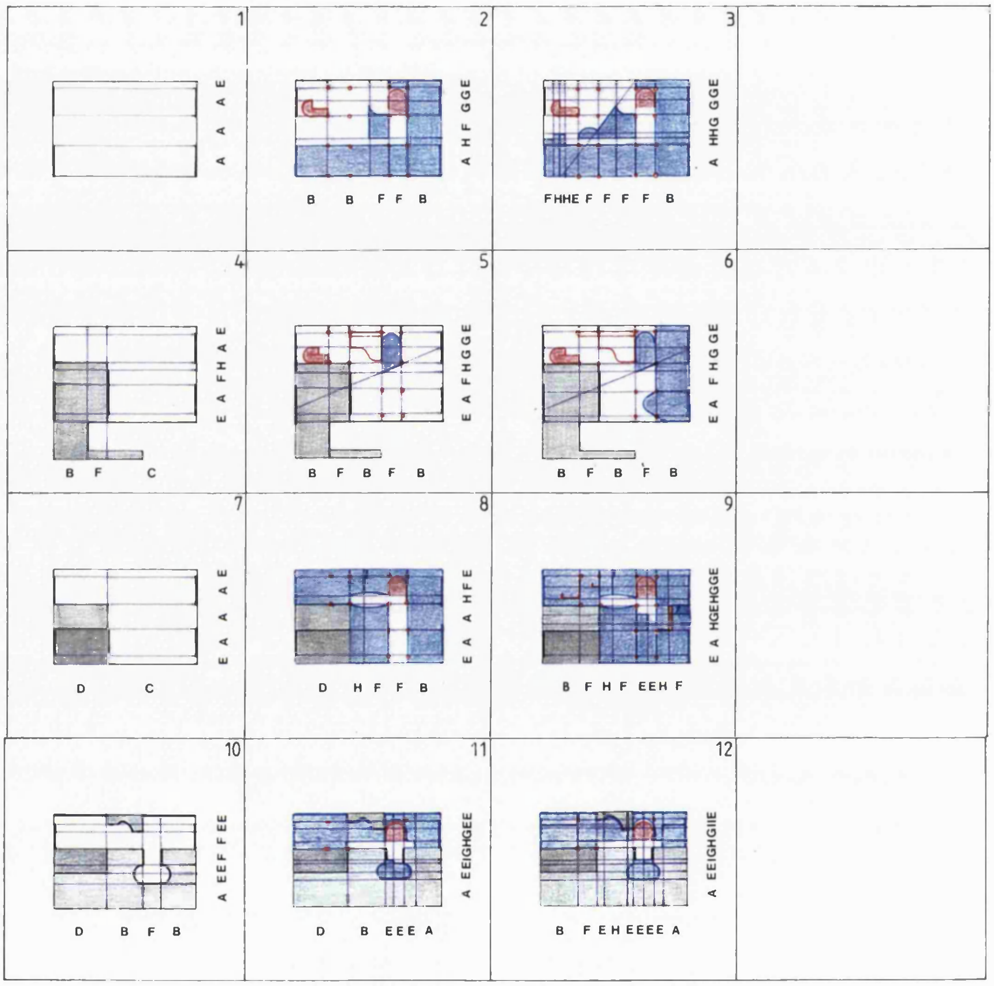


Table LH1 4.2
**Grid Geometrical Properties**

At the first floor the grid consists of five geometrical bays at length that progress according to the following sequence: B F B F B, (TLH1 4.2, fig. 5). Although the sequences of grid bays indicate overall symmetry, the oblique line breaks the symmetrical pattern. The Symmetry Grid index is: 0.85. Thus, there is 'just about' symmetry in this organisation, (TLH1 4.4, p. 265). At width the arrangement of the grid bays is as following: E G G H F A E. This is not a symmetrical and tripartite arrangement.

At the second floor the grid bays at length progress according to the following sequence: D H F F B, (TLH1 4.2, fig. 8). There is no symmetry and tripartition in this direction. At width the geometrical bays proceed as following: E F H A A E. The Symmetry Grid index is 0.85, (TLH1 4.4, LR, p. 265). This arrangement is 'just about' symmetrical and tripartite.

At the third floor the grid bays at length are based on the following rhythm: D B E E E A, (TLH1 4.2, fig. 11). At width the grid bays are organised according to a E E G I E E A sequence. None of these sequences is symmetrical and tripartite.

The structural grid consists of five geometrical bays at length arranged according to the sequence: B F B F B, (TLH1 4.3, fig. 1-10, p. 264). At width the structural grid bays progress as following: E A A A E. These are both symmetrical and tripartite patterns.

Looking at the relationship between the elements of the structural grid and the elements of the physical grid it turns out that at the first and the third floor every single line of the former coincides with a line of the latter, (TLH1 4.3, fig. 3, 9, p. 264). At the ground and the second floor only one line of the structural grid does not coincide with a line of the physical grid, (TLH1 4.3, fig. 1, 5, p. 264).

Examining the relationship between the lines of the interior and those of the exterior, it turns out that at the ground floor four out of ten lines, (4/10), defining the elements of the interior coincide with the lines defining the elements of the exterior, (I/O line index: 0.40, TLH1 4.5, p. 265). At the first and the second floor this ratio is two to eight, (2/8), and six to nine, (6/9), respectively, (I/O index: 0.25, 0.66). Finally, at the third floor ten out of fourteen lines, (10/14), of the internal articulation coincide with lines of the external articulation, (I/O line index : 0.71).

At stage three six shapes are superimposed on the ground floor, (TLH1 4.1, fig. 3, p. 262). Five of these elements are arranged along the periphery of the volume sharing their defining surfaces with the surfaces of the block.

At the first floor a spatial and a curvilinear rectangle are superimposed at the right side of the plan, (TLH1 4.1, fig. 6, p. 262). These shapes also share their surfaces with the outer surfaces of the block.

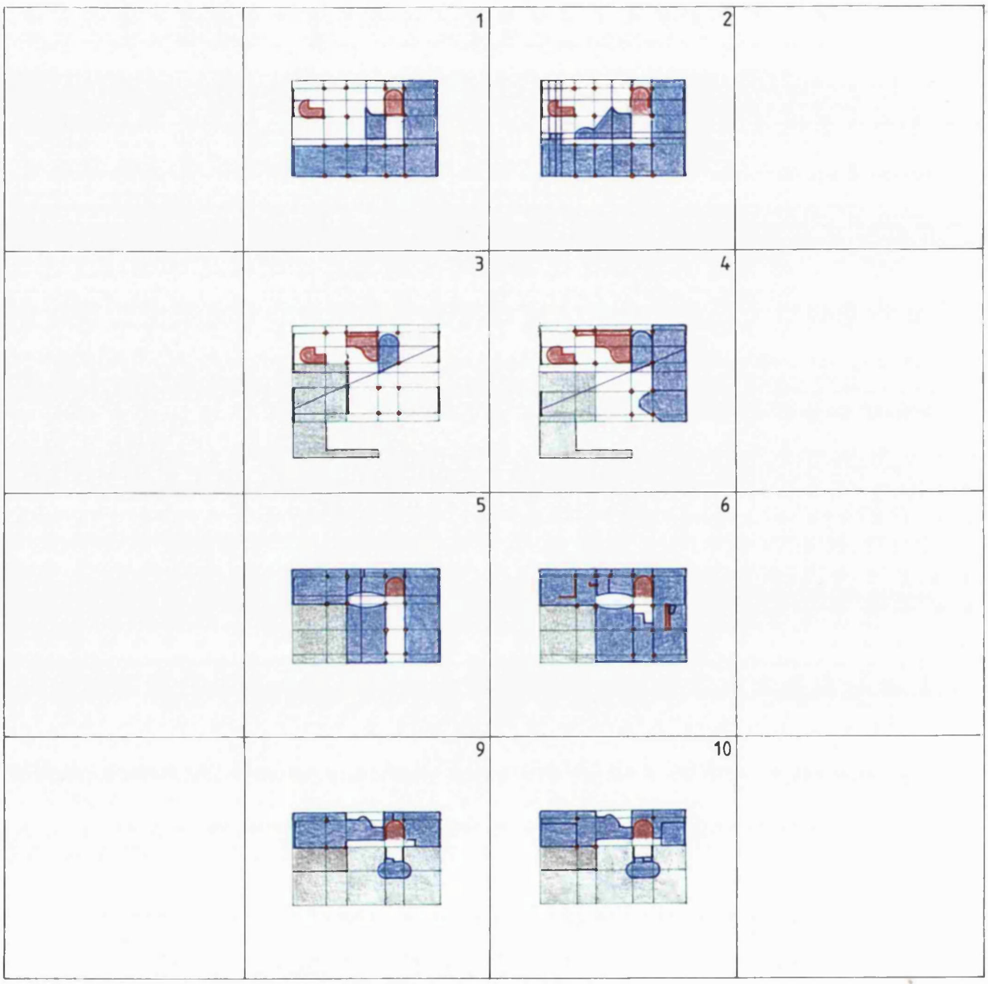


Table **LH1 4.3**
**Structural Grid Geometrical Properties**

At the second floor a rectangle and a L shaped element are superimposed in between the two bedrooms opposite the staircase, (TLH1 4.1, fig. 9, p. 262). Further, two Ls and a small trapezoidal shape are superimposed on the shape introduced at the right side of the plan at stage two. The two Ls interlock sharing their defining surfaces with the outer surfaces. Finally, two L shaped screens are added inside the bedroom at the left side of the composition.

At the third floor the shape superimposed at the left side of the plan at stage two is subdivided by the superimposition of two interlocking Ls, (TLH1 4.1, fig. 12, p. 262). The shape at the right side of the plan superimposed at stage two is also transformed into two interlocking shapes.

There is no overall symmetry characterising the organisation of the shapes in any of these floors, (TLH1 4.1, fig. 3, 6, 9, 12, p. 262). At the ground floor the grid bays progress at length according to the sequence: F H H E F F F F B. The rhythm of the grid bays at width is: E G G G H H A, (TLH1 4.2, fig. 3, p. 263). There is no symmetry and tripartition in any direction.

At the first floor the sequence of the grid bays is as described at the previous stage. Thus, the grid at length remains 'just about' symmetrical and tripartite, (TLH1 4.2, fig. 6, p. 263). At width the geometrical bays progress according to the following sequence: E G G H F A E. This is not a symmetrical and tripartite pattern.

At the second floor the geometrical bays are arranged at length as following: B F H F E E H F, (TLH1 4.2, fig. 9, p. 263). At width the geometrical bays progress according to the following rhythm: E G G H E G H A E. There is no symmetry and tripartition in any of these patterns.

At the third floor the grid bays progress at length as follows: B F E H E E E E A. The AS index is 0.80, (TLH1 4.4, p. 265). Thus, the arrangement of the grid bays at length is 'just about' symmetrical and tripartite. At width the organisation of the grid bays is as following: E I I G H G I E E A. There is no symmetry or tripartition characterising the grid in this direction.

Looking at the relationship between the lines of the interior and those of the exterior it turns out that at the ground floor four out of nineteen lines, (4/19), of the former coincide with lines defining the latter, (I/O line index: 0.21), (TLH1 4.5, p. 265). At the first floor this ratio is four to eleven, (4/11, I/O line index: 0.36). At the second floor six out of seventeen lines, (6/17), defining the elements of the internal articulation coincide with the lines defining the elements of the external articulation, (I/O index: 0.35). Finally, at the third floor twelve out of nineteen lines, (12/19), of the interior coincide with the lines of the exterior, (I/O line index: 0.63).

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.50 | 0.63 |
| 1ST | 0.50 | 0.85 | 0.85 |
| 2ND | 0.66 | 0.66 | 0.60 |
| 2ND | 0.80 | 0.57 | 0.80 |

Table **LH1 4.4**
**SYMMETRY GRID INDEX, (BF)** - No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.80 | 0.57 | 0.44 |
| 1ST | 0.85 | 0.66 | 0.66 |
| 2ND | 1 | 0.85 | 0.60 |
| 2ND | 0.50 | 0.40 | 0.36 |

Table **LH1 4.4 LR**
**SYMMETRY GRID INDEX, (LR)** - No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.40 | 0.21 |
| 1ST | | 0.25 | 0.36 |
| 2ND | | 0.66 | 0.35 |
| 2ND | | 0.71 | 0.63 |

Table **LH1 4.5**
**INSIDE/OUTSIDE LINE INDEX** - No of geom lines of internal and external elements/Total no of lines

## • COMPARISON ACROSS STAGES

### • Physical properties

At stage one glazed material defines the surfaces of the block extending at length at the ground floor, (TLH1 4.1, fig. 1, p. 262). On the other hand, those stretching at width are defined by both glazed and opaque surfaces. The distribution of both kinds of material along the surfaces of this shape destroys its uniform contour. The transparent definition of its corner questions the solidity of this element and its property to read as a volumetric component.

At the first and second floor the surfaces of the block, the void and the volumetric L extending at length are defined by glazing, whereas those extending at width are defined by both opaque and glazed surfaces, (TLH1 4.1, fig. 4, 7, p. 262). Besides, all corners of these elements apart from two[24] are defined by glazed surfaces.

Thus, there is no clear distinction between the block, the void and the volumetric L articulated by a distinction between the material and the thickness of their defining elements. The similar physical treatment of these components and their planar decomposition creates an interaction of planes rather than an hierarchical composition in which one shape prevails over the others.

At the third floor the largest element is a U with an elliptical shape attached to its front surface, (TLH1 4.1, fig. 10, p. 262). Similarly to the floors below, a simultaneous definition of corners by opaque and transparent boundaries analyses this shape into planar components.

The corners defining the L shaped terrace at the back do not have a uniform treatment. Three of these corners have an opaque and glazed physical definition, while the fourth one is defined by opaque surfaces only. The decomposition of the left corner into an opaque and a glazed plane allows the outer surface of the volume to continue towards the definition of a large rectangle. On the other hand, the volumetric characteristics of the right corner disrupt this continuity. This causes the groupings of the outer surfaces to oscillate between two conflicting readings: the U and a rectangle. Thus, similarly to the ground, first and second floors there is no clear distinction between elements. A combination of volumetric and planar readings interact freely complementing each other.

At stages two and three one at least of the surfaces of the superimposed shapes at the ground, second and third floor coincides with a surface of the largest components, (TLH1 4.1, fig. 2, 5, 7, 11, p. 262). This coincidence increases the complexity of the configuration by forcing the boundaries of the block, the L

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24 These are the left front corner of the block that lacks full physical definition and the left front corner of the volumetric L that is defined by an opaque and a glazed surface.

and the U to group themselves towards both the largest and the smaller elements. In this respect the clarity of the initial shape is undermined further.

One at least corner of the superimposed shapes is either defined by both transparent and opaque material or lacks complete physical definition accommodating a door entry. Similalry to the elements of the large scale, the elements of the small scale are transformed to volumetric and planar constituents. This weakens the distinction between the initial shape and the secondary elements.

Further, at the second and third floors the majority of the superimposed shapes interlock joint together by a mutual interconnection of parts, (TLH1 4.1, fig. 2, 3, 5, 6, 8, 9, 11, 12, p. 262). For example, the staircase and the superimposed element at its left side at the second floor, (TLH1 4.1, fig. 8, p. 262), interpenetrate sharing a curved surface. It has been already suggested that in interpenetrating shapes boundaries enter into multiple distributions. Each time a distribution prevails completing one shape the other fades into the background. An extensive use of interlock relations in these plans multiplies the participation of surfaces into shape formations increasing the degree of attention necessary to capture the local scale configuration.

However, a classification of surfaces according to material and thickness distinction takes place. This classification arranges all thick and transparent surfaces along the periphery of the block, the L or the U while attributing an intermediate thickness to the shapes of the interior. Besides, a planar decomposition of the superimposed elements at the points of intersection of their defining elements with the outer surfaces allows these surfaces to continue towards the completion of the largest scale components, (TLH1 4.1, fig. 2, 3, 5, 6, 8, 9, 11, 12, p. 262).

Nevertheless, although the outer surfaces are differentiated, the planar configuration of the large and the small scale elements sustains a conflict between the elements of the external and the internal articulation as well as between the elements of the internal articulation themselves. A network of interacting volumes and planes are created none of which becomes the overall statement about the building as a whole.

- **Geometrical properties**

A comparative analysis of stages shows that there is no overall shape symmetry governing the disposition of shapes throughout the stages, (TLH1 4.1, fig. 1-12, p. 262). Moving to the properties of the grids analysis shows that the ground floor grid at length moves from symmetry at stage one to asymmetry, (TLH1 4.2, fig. 1, 2, 3, p. 263, TLH1 4.4, p. 265). At the first floor it moves from asymmetry to 'just about' symmetry and tripartition at stages two and three, (TLH1 4.2, fig. 3, 4, p. 263, TLH1 4.4, p. 265). The second and third floor grid remains asymmetrical throughout the stages, (TLH1 4.1, fig. 7, 8, 9, p. 262, TLH1 4.4, p. 265). Finally, at the third floor the grid moves from 'just about' symmetry to asymmetry at stage two and 'just about' symmetry at stage three, (TLH1 4.2, fig. 10, 11, 12, p. 263, TLH1 4.4, p. 265).

At width the organisation of the grid is not symmetrical and tripartite in any stage, (TLH1 4.4, LR, p. 265). It is only the second floor grid at stage one and two that is characterised by symmetry and tripartition, (TLH1 4.2, fig. 7, 8, p. 263, TLH1 4.4, LR, p. 265). Therefore, there is no consistent pattern of relation amongst the grid properties of each stage and the properties of the next one

*There is no consistent pattern of relation between the external and the internal articulation either.* Thus, at the ground floor the symmetrical exterior at length is contrasted with the asymmetrical interior at the following stages. Further, the asymmetrical exterior of the first floor is contrasted by the symmetrical interior at stages two and three, (TLH1 4.4, LR, p. 265). Besides, at third floor symmetry and asymmetry alternate in a way in which at one stage the properties of the interior coincide with those of the exterior while at another they do not.

Looking at the relationship between the shape and the grid organisation it turns out that at the first floor at stage two and three as well as at the third floor at stage three a dissociation between the two kinds of properties takes place, (TLH1 4.4, p. 265). This dissociation is expressed by a contrast between an asymmetrical organisation of shapes and a symmetrical organisation of grid lines. In these cases the obvious symmetries of the shape organisation are replaced by subtler symmetries of the grid organisation.

Coming the relationship between the physical and the structural grids, there is no consistent pattern of relationship in either of the two directions, (TLH1 4.2, fig. 1-12, p. 263, TLH1 4.3, fig. 1-10, p. 264). Thus, at the ground floor a dissociation is created between the asymmetrical organisation of the physical grid and the symmetrical and tripartite organisation of the structural grid along both directions, (TLH1 4.2, fig. 2, 3, p. 263, TLH1 4.3, fig. 1, 2, p. 264). At the first floor an association between the physical grid and the structural grid is constructed at length based on a coincidence between their geometrical properties, (TLH1 4.2, fig. 5, 6, p. 263, TLH1 4.3, fig. 3, 4, p. 264). At width there is no such association. At the second floor there is no association between the properties of the two grids, (TLH1 4.2, fig. 8, 9, p. 263, TLH1 4.3, fig. 5, 6, p. 264). Finally, at the third floor an association is constructed only at stage three, (TLH1 4.2, fig. 12, p. 263, TLH1 4.3, fig. 10, p. 264).

The I/O line index at the ground floor drops from 0.40 at stage two to 0.21 at stage three, (TLH1 4.5, p. 265). At the first floor it increases from 0.25 to 0.36. At the second and third floor it drops from 0.66 to 0.35 and from 0.71 to 0.63 respectively. It is only at the third floor that a certain degree of coincidence amongst the lines of the interior and those of the exterior takes place. The lack of coincidence in the rest of the floors indicates that there are no overall rules determining the positions of the elements of the internal articulation.

To summarise, there is a lack of a consistent pattern of application of symmetry along the analytic stages. Therefore, there is no overall rule applied from the first to the last stage and from the exterior to the interior. Besides, a different pattern of development of symmetry/asymmetry takes place in each floor. This shows that each individual level is organised according to a different principle.

There is also a lack of overall rules determining the placement of the internal partitions. Thus, there is no extensive physical definition of the grid lines defining the elements of the external and those of the internal organisation. The grid systems are treated as regulating diagrams that are 'buried' behind the sculptural articulation of the walls. An increase in the number of lines defining the elements of the interior increases the complexity of these diagram. To decipher the network of lines one cannot rely on observations of a 'naked eye'. One would have to draw it on paper in order to 'see' and study its logical relations.

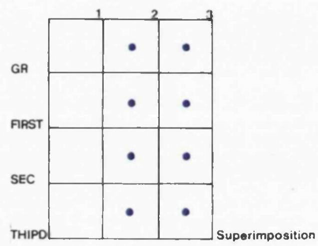

Table LH1–S

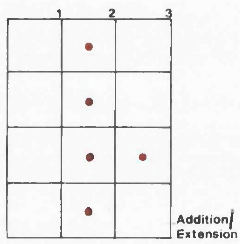

Table LH1–A/E

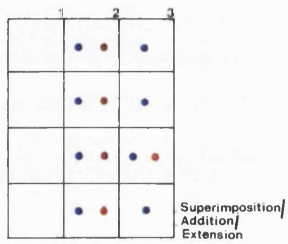

Table LH1–S/A/E

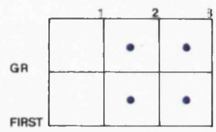

Table LH2–S

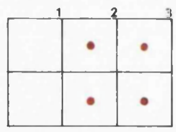

Table LH2–A/E

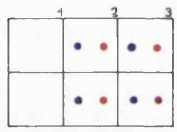

Table LH2–S/A/E

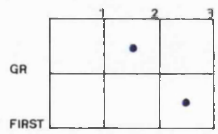

Table LH3–S

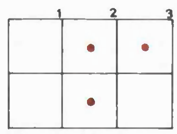

Table LH8– A/E

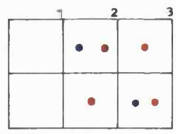

Table LH8–S/A/E

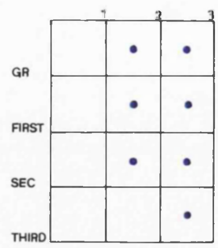

Table LH4–S

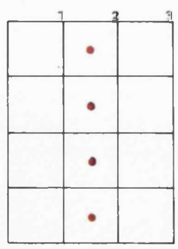

Table LH4–A/E

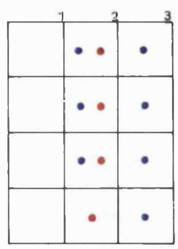

Table LH4–S/A/E

## • COMPARISON ACROSS LE CORBUSIER'S HOUSES

In this section a comparative analysis across Le Corbusier's houses is attempted. The aim is to identify recurrent similarities and differences that can lead to a better understanding of the problems raised at the beginning of this chapter. The questions addressed in this section are:

- Is there a pattern characterising the transformation process?
- Which are the rules that govern this process?
- Is there any relationship among the properties of the external and the properties of the internal articulation?

## • THE PATTERNS OF THE TRANSFORMATION PROCESS

### • Operations and their order of occurrence

At stage one the floor plans are described either by a simple shape, like a rectangle, (TLH1 4.1, fig. 1, p. 281, TLH4 4.1, fig 7, 10, p. 288), or a planar L, (TLH1 4.1, fig. 4, 7, p. 281, TLH3 4.1, fig. 1,4, p. p. 286, TLH4 4.1, fig 1, p. 288), or a curvilinear shape, (TLH2 4.1, fig. 1, p. 284) or a more complicated shape resulting from the subtraction and addition of more than one components from the block, (TLH1 4.1, fig. 10, p. 281, TLH2 4.1, fig. 4, p. p. 284, TLH4 4.1, fig. 4, p. 288).

At the following stages the plans are transformed by the operations of superimposition and addition/extension. Tables TLH-S and TLH-A/E present these operations in relation to the stages they occur[25]. They seem to show that addition occurs mainly at stage two[26], while superimposition takes place in both stage two and three[27].

*Thus, there seems to be a consistency in the transformation pattern associating addition with stage two and superimposition with both stages two and three. Thus, the operations transforming the interior have a consistent pattern of occurrence.*

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25 At the ground floor of LH2 the repositioning of the columns is considered as an operation of addition.

26 The operation of addition/extension at stage three occurs only in four out of twelve plans, (4/12).

27 The only exceptions are the first floor of LH3 at stage two, (TLH1 4.1, fig. 5, p. 281), the ground floor of the same house at stage three, (TLH1 4.1, fig. 3, p. 281), and the third floor of LH4 at stage two, (TLH4 4.1, fig. 10, p. 288).

# • THE RELATIONAL LOGIC OF TRANSFORMATIONS

## • Types of shapes and types of combinations

### • Addition/Extension

Addition at stage two introduces elements like staircases and ramps, (TLH1 4.1, fig. 2, 5, 8, 11, p. 281, TLH2 4.1, fig. 2, 5, p. 284, TLH3 4.1, fig. 5, p. 286, TLH4 4.1, 2, 5, 7, 11, p. 288). In all houses two elements of circulation, either a staircase and a ramp or two staircases are introduced[28].

These elements are either free standing elements[29], or they are attached either to one of the outer surfaces[30], or to one of the surfaces of a superimposed element[31]. There is a tendency to adopt either curvilinear elements accommodating a staircase or rectilinear shapes accommodating a ramp. There is also a tendency either to detach these elements from the rest of the shapes or to attach them to an external surface. Thus, there seems to be a preference regarding the appearance of the elements of circulation as well as their relation with the other elements in the configuration.

Addition at stage two also introduces voids connecting the floors together. Thus, in LH1 a piano shaped opening connects the ground and the first floor, (TLH1 4.1, fig. 5, p. 281). In LH3, a rectangular opening connects the two floors, (TLH3 4.1, fig. 5, p. 286), while in LH4 two rectangular openings connect the first and the second and the second and third floors respectively, (TLH4 4.1, fig. 7, 11, p. 288).

Addition at stage three introduces internal partitions inside superimposed shapes subdividing these shapes into smaller areas, (TLH1 4.1, fig. 9, p. 281, TLH2 4.1, fig. 6, p. 284). These are either planar elements or volumetric components functioning like wardrobes, shelves and sanitary units.

### • Superimposition

Superimposition at stage two introduces components that are either attached to the periphery of the plan occupying the corners, or they extend from one extreme side of the plan to its centre or they share none of their defining elements with the surfaces of the block. Thus, there is not a certain pattern in which the superimposed shapes relate to the shapes of the external articulation. However, one of the defining surfaces of these elements coincides with one of the outer surfaces.

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28 The only exception is one of the two staircases at the first floor of LH1, (TLH1 4.1, fig. 5), and at the ground floor of LH3, (TLH3 4.1, fig. 2), that are superimposed rather than added on the plans.

29 These are the staircase at the left at LH1, (TLH1 4.1, fig. 2, 3, 5, 6), the spiral staircase at LH2, (TLH2 4.1, fig. 2, 3, 5, 6), and the staircase at the back at LH3, (TLH3 4.1, fig. 5, 6).

30 The ramp in LH2, (TLH2 4.1, fig. 2, 3, 5, 6, p. 284), the front staircase and the ramp in LH3, (TLH3 4.1, fig. 2, 3, 5, 6, p. 286).

31 The staircase at the right at LH1, (TLH1 4.1, fig. 5, 6, p. 281), and the staircase at LH4, (TLH4 4.1, fig. 2, 3, 5, 6, p. 288).

At stage three superimposition continues either introducing more shapes on the plans, (TLH1 4.1, fig. 6, p. 281, TLH2 4.1, fig. 3, 6, p. 284, TLH3 4.1, fig. 6, p. 286, TLH4 4.1, fig. 12, p. 288), or subdividing the existing ones into smaller shapes, (TLH1 4.1, fig. 3, 9, 12, p. 281, TLH2 4.1, fig. 3, 6, p. 284, TLH4 4.1, fig. 3, 6, 9, p. 288). Thus, there is a consistent pattern of transformations produced by superimposition at this stage also.

The shape of the superimposed components varies from the simplest one, i.e. a rectangle, to more complicated ones like a U or a L or to even more complicated shapes like the one superimposed at the back left corner of the first floor of LH2, (TLH1 4.1, fig. 5, p. 281). Thus, from a first point of view there seems to be no consistent employment of a particular shape.

Looking at these shapes it turns out that apart from the curvilinear shapes and the Ls there is no similarity among the rest of the irregular shapes. Figures 4.6 - 4.18, (p. 292), present these shapes in isolation, i.e. independently of the context in which they are placed to examine whether there is any underlying similarity among them.

A close examination shows that these elements are all concave shapes consisting of both concave and convex corners. The dotted lines in these figures represent the extensions of the extreme surfaces of these shapes. These extensions are drawn in a way that a simple shape like a rectangle or a triangle to which each shape is inscribed is created.

Looking at these figures it turns out that the concave shapes result from the subtraction of a rectangle or of a L shape or a curvilinear shape from the corners of these rectangles. *Thus, although the irregular shapes superimposed on the plans have different appearance they have a common characteristic regarding the ways they relate to a simpler shape inherent in their description.*

Le Corbusier's volumetric articulation was showed to be preoccupied with the transformation of a simple volume into a concave volumetric component. Thus, it seems that the tendency to adopt shapes the surfaces of which undulate in an orthogonal or curved manner characterises also the internal organisation. These surfaces endow the elements with a jig-saw puzzle appearance, fig. 4.8, 4.15, 4.18, (p. 292).

Looking at the ways these components relate to each other, it turns out that they interpenetrate joint together by a mutual interconnection of parts. In other words, they are joint together like jig-saw puzzle units sharing a common boundary. *Thus, there is a certain general category of shapes that are used as well as a certain way in which these shapes relate to each other.*

*It turns out that there is not only a certain transformational logic that the architect employs in the articulation of the interior, but also a certain category of shapes and a certain type of shape combination. This category is broad enough to allow individual variation that distinguishes the visual appearance of each interior from the others.*

- **Rules of combinations**

- **Physical properties**

Volumetric Analysis suggested that excavation of the block occurs always at the corner undermining its explicit definition as a physically complete object. It also suggested that although planar extension restores its completion, it creates an awareness rather than an actual physical definition of the block.

It also argued that planar extension assigns volumetric and planar readings to the block, as well as to the volumetric constituents, resulting from excavation. These readings undermine the volumetric clarity of these elements creating an interaction of volumes and planes.

Interior analysis at stage one focused on the ways this decomposition interacts with the distribution of material used to define these elements and with the thickness of their contour. It suggested that these parameters not only do not clarify the hierarchical relations between the large and the small scale components but also accentuate their interaction and decompose them further.

Thus, the surfaces of these elements are defined by both transparent and opaque material. Besides, their corners are defined either by transparent or by both transparent and opaque material[33]. In other words, there is no pattern of differentiation between these constituents based on a difference in the materials defining them.

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33 There are cases in which one at least corner of a constituent is defined by opaque surfaces only. These are the back and front right corner of the block in LH3, (TLH3 4.1, fig. 1, p. 281), the two back corners of the second floor plan in LH4, (TLH4 4.1, fig. 7, p. 288), and the left back corner of the third floor of the same house, (TLH4 4.1, fig. 10, p. 288). However, these are rare cases showing that there is a strong tendency to dematerialise the corners of the volumes in defiance of their volumetric character.

Besides, there is no uniform treatment of the volumetric components in terms of material that defines their contour. This together with the definition of their corners either by transparent or by both transparent and opaque surfaces analyses them into planes. Therefore, the material definition of the volumes reveals a consistent tendency to decompose them into an interaction of volumetric and planar components.

To use an example, at the first floor of LH1 the block, the volumetric L and the void are all defined by opaque and transparent surfaces, (TLH1 4.1, fig. 4, p. 281). Besides, all corners of these elements are defined by transparent surfaces, apart from the front left corner of the volumetric L which is defined by both transparent and opaque surfaces[34].

All elements are given equal weight in terms of the type of material used and the ways in which this material is distributed along their contour. Besides, the planar decomposition of their corners establishes planar readings that interact with the volumetric ones.

Thus, on the one hand the surfaces defining these elements group themselves to complete their contour and on the other release themselves acting as individual entities. Looking at the plan one has to accommodate two opposing interpretations. One attaches finite readings recognising the extensions of lines and their ability to complete contours, while the other recognises a potential energy at work in which segments of lines distribute themselves independently of the first line of action.

At stage two superimposition creates simultaneous readings of the elements of the volumetric articulation and those of the internal articulation. This is achieved by a distribution of the superimposed elements along the periphery of the plan in a way that the outer surfaces define both the exterior and the interior components.

The ways material contributes to the recognisability of the interior shapes was found similar to the ones of the shapes of the external articulation. Thus, the shapes superimposed on the plans are also defined by opaque and glazed surfaces. Besides, their corners are defined either by opaque surfaces or by transparent surfaces or by both opaque and transparent ones.

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34 The representation of material definition of the surfaces and corners of these elements in two dimensions is different from their actual material articulation. Thus, in a plan conventions of representation show the front and back surfaces glazed. In reality fenestration defines long horizontal strips along these surfaces in a way that opaque and glazed material alternates along their height, (Illustration 4.19, p. 260). However, although solid and transparent definition alternate along the surfaces and the corners of the block the linear extension of the strips up to the corners of the volume give the back and the front surfaces the character of a membrane.

Therefore, similarly to the elements of the volumetric articulation, those of the internal articulation are not characterised by a uniform contour. Further, they provide both volumetric and planar readings. In this way, the interaction amongst the shapes of the interior and those of the exterior produced by the simultaneous definition of these elements by the same surfaces becomes more complicated. This is because there is a *consistent tendency to decompose and break any direct and straightforward definition of shapes. It is also because there is a tendency to suspend* any scale distinction amongst them articulated along the contrast of volumetric/planar, opaque/transparent, complete/incomplete.

Analysis also showed that a number of the superimposed shapes are complex ones that interlock sharing undulating surfaces. In Volumetric Analysis it was suggested that interlock is widely employed in the external articulation. The solid and void components were found to be joint together by a mutual interpenetration of parts. This interpenetration was shown to operate in two as well as in the third dimension, fig. 4.15-4.21, (p. 292).

It was suggested that interlock creates an ambiguous situation in which each unit is physically completed by the same boundaries defining another one. The same phenomenon characterises the superimposition of an elementary shape like a rectangle on another one, fig. 4.19, 4.20, (p. 292). However, in fig. 4.19 the large and the small rectangles share two surfaces and a corner. In fig. 4.20, (p. 292), the two shapes share three surfaces and two corners. Thus, the physical elements that two shapes share in the former are less than those in the latter.

Further, in fig. 4.19, (p. 292), the common corner is a convex one. In fig. 4.20, (p. 292), two of the corners the shapes share function as convex corners for one shape and concave corners for the other one. In fig. 4.19 the corner defining both shapes provides one reading only, i.e. convex, whereas in fig. 4.20 the two corners provide two readings, i.e. convex and concave.

Thus, in the first figure the common corner has a single depiction, whereas in the second one two of the common corners have a dual depiction. This coupled to the difference in the number of surfaces that play a dual role makes the first configuration simpler than the second one and therefore much easier understood.

Thus, the interlock relations created amongst the elements of the interior create interacting readings of shapes. It seems that multiple levels of interaction are created that regulate the relations amongst the elements of the large scale, the elements of the large and those of the small scale as well as amongst the elements of the small scale.

However, these multiple readings seem to be contrasted by a distinction of the outer boundaries from the internal partitions. This is based on a distinction of thickness of surfaces. Thus, the former appear considerably thicker from the latter differentiating the elements of the external articulation from those of the internal one.

Further, fenestration is another means by which the outer boundary is distinguished from the rest of the surfaces. Thus, whereas the planar qualities ascribed to all surfaces homogenise the physical elements of both the interior and the exterior, the ribbon windows puncturing the outer surfaces become patterns of differentiation.

Addition introduces elements on the plans that are either free standing or attached to an external or to an internal surface. The free standing elements reveal a tendency to create an independence between the outer surfaces and the internal elements, whereas the attached ones reveal the opposite. Thus, there is no consistent pattern in which the added components relate to the surfaces defining the rest of the elements.

The free standing elements do not affect the physical definition of the large scale elements. Besides, the ones that are attached to the outer surfaces have a minor influence to the readings constructed by them. This is because the added components are not perceived as complete shapes that could undermine the groupings of the large scale physical elements towards the completion of the large scale components.

- **THE PHYSICAL PROPERTIES IN RELATION TO INTELLIGIBILITY**

The physical articulation of the interior continues the decomposition of the volumes that define the external articulation of the houses. The shapes of the interior, their positions and the distribution of material along their contour analyses the configuration into a system of interacting volumes and planes.

Thus, both the interior and the exterior are characterised by the same logic. According to this logic interacting readings are constructed that challenge the hierarchical relations amongst the large and the small scale components.

The 'jig-saw' puzzle combinations of the shapes of the interior complicate the configuration further. This is because they introduce multiple readings that are in a constant conflict in relation to one another. Looking at the interiors of these houses one is aware of multiple levels of interaction never resolving themselves into a single reading.

- **GEOMETRICAL PROPERTIES**

- **Shape geometrical properties**

Moving to the geometrical properties analysis starts by an examination of these plans as geometrical arrangements of shapes. In the previous chapter it was suggested that regardless of the asymmetrical structuring of the volume as a whole, there are local symmetries organising certain individual levels. These symmetries mainly regulate relations amongst the large scale components.

This analysis shows that the distribution of shapes on these plans is not characterised by overall or 'just about' symmetry in either stages two or three. There are no local symmetries governing the positions of individual elements either. Thus, there is no hierarchical application of a single rule from the first to the last stage and from the largest to the smallest components. Therefore, the local symmetry characterising the large scale volumes of the external organisation is contrasted by the overall asymmetry of the plan organisation.

- **GRID GEOMETRICAL PROPERTIES**
- **Physical grid**

Looking at these plans as configurations of grid lines created by the extensions of the defining elements of shapes, it turns out that eight out of twelve plans, (8/12), at stage one are symmetrical and tripartite or 'just about' symmetrical and tripartite. These are the ground floor grid of LH1 and LH2, the first floor grid of LH2, (TL 4.1, p. 291), the second and third floor grid of LH1, (TL 4.1, TL 4.1, LR, p. 291), the ground and first floor grids of LH3, (TLH3 4.4, diag axis, p. 527), as well as the second floor grid of LH4, (TL 4.1, TL 4.1 LR, p. 291).

More specifically, the grids of the ground floor of LH1, LH2 as well as the second floor of LH4 are symmetrical and tripartite on the BF axis. The third floor grid of LH1 and the first floor grid of LH2 are 'just about' symmetrical and tripartite on the same axis. The second floor grid of LH1, as well as the second floor grid of LH4 are 'just about' symmetrical and tripartite on the LR axis, (TL 4.1, LR, p. 291). Finally, the grids of both floors of LH3 are symmetrical on the diagonal axis of the block, (TLH3 4.4, diag axis, p. 527).

At stage three four out of twelve grids, (4/12), are characterised by 'just about' symmetry and tripartition. These are the first and third floor grid of LH1, (TL 4.1, p. 291), the ground floor grid of LH2, (TL 4.1, p. 291) and the second floor of LH4, (TL 4.1, p. 291). Finally, the third floor grid of LH4 is symmetrical and tripartite on the BF axis, (TL 4.1, p. 291).

Thus, from stage one to stage three the geometrical organisation of the grids moves from overall symmetry or 'just about' symmetry to asymmetry in the majority of the plans. In this respect, the asymmetrical and non tripartite organisation of the interior contrasts the symmetrical and tripartite organisation of the exterior. This shows that there is no single rule applied from the first to the last stage as well as from the external to the internal organisation .

The grids exhibiting symmetry at stage one are not characterised by a consistent pattern of development along stages two and three. Thus, the ground floor grid of LH1 starts by overall symmetry on the BF axis at stage one and moves to asymmetry at the following stages, (TL 4.1, p. 291). The ground and second floor grid of LH3 starts with symmetry on the diagonal axis and moves to asymmetry at stage two and three, (TLH3 4.4, diag axis, p. 527). The second floor grid of LH1 and LH4 moves from symmetry on the LR axis at stage one to asymmetry at the following stages, (TL 4.1, LR, p. 291).

In other cases symmetry and asymmetry alternate along the analytic sequences. Thus, the third floor grid of LH1 moves from 'just about' symmetry and tripartition on the BF axis at stage one to asymmetry at stage two and 'just about' symmetry at stage three, (TL 4.1, p. 291).

Besides, there are cases like the first floor grid of LH1 which move from overall asymmetry at stage one to 'just about' symmetry at the following stages, (TL 4.1, p. 291). Besides, the third floor grid of LH4 moves from overall asymmetry at stage one to overall symmetry on the BF axis at stages two and three, (TL 4.1, p. 291).

In these cases symmetry is imposed on the plan by the articulation of the small scale elements of the interior. Thus, a contrast is constructed between the large and the small scale, the internal and the external organisation. This is based on an asymmetrical and non tripartite interior and on a 'just about' symmetrical and tripartite interior.

Finally, at the second floor of LH1 and the ground floor of LH4 the grid moves from overall symmetry with respect to the LR axis, (LH1) and overall asymmetry, (LH4) at stage one to 'just about' symmetry at stage two and overall asymmetry at stage three, (TL 4.1, LR, p. 291).

To summarise, the examination of the grid properties shows that:

- *The majority of the grids move from overall symmetry at stage one to overall asymmetry at the final stage. Thus, a dissociation is constructed between the properties of the internal and those of the external articulation.*
- *There is no consistent pattern of occurrence of symmetry/asymmetry along the analytic stages. There are cases in which asymmetry is followed by symmetry, cases in which symmetry is followed by asymmetry, and cases in which symmetry and asymmetry alternate along the analytic sequences.*
- *The lack of a consistent pattern of application of rules shows that the interior in process is not controlled by a single rule employed from the first to the last stage and from the interior to the exterior.*

Le Corbusier has been often seen as being concerned with a contrast between a simple exterior and a complicated interior accommodating the contingencies of everyday life[35]. These suggestions are usually based on surface descriptions that concentrate on the figurative appearance of the volume and the internal complexities of the plan..

*This analysis shows that the contrast between interior and exterior is not only visual in nature, based on the homogenous panels of villa Savoie versus the sculptural gestures of the internal partitions, but also geometrical based on contrasts between their geometrical grids.*

- **Structural grids - The relationship between the structural and the physical grid**

The structural grids are generally characterised by an equal spacing of geometrical intervals along both directions, (TLH2 4.3, fig. 1-4, p. 285, TLH3 4.3, fig. 1-4, p. 287, TLH4 4.3, fig. 1-8, p. 290). The only exception is the organisation of the structural grid of LH1 at length which is based on an alternation of wide and narrow geometrical intervals, (TLH1 4.3, fig. 2, 3, 4, 5, 6, 7, p. 283). Besides, the structural grid of LH3 at width at stage three is not characterised by any symmetrical distribution of the geometrical bays on any axis, (TLH3 4.3, fig. 2, 4, p. 287).

In LH2, LH3 and LH4 the equal spacing of the structural grid contrasts either the lack of any overall geometrical pattern of the physical grid or its tripartite organisation which distinguishes a central geometrical bay from the rest. In LH1 the only contrast articulated between the two types of grids is based on a contrast between the asymmetrical organisation of certain physical grids and the symmetrical and tripartite organisation of the structural grid at length, (TLH1 4.2, fig. 2, 3, 4, 7, 9, 11, p. 282, TLH1 4.3, fig. 1-8, p. 283).

The same contrast was found to operate between the physical and the structural grids of the volumetric articulation. Volumetric analysis suggested that the two grids are treated as independent systems. This analysis shows that in the interior the two grids are also treated independently of each other. Thus, similarly to the Volumetric Analysis it enriches the definition of the 'free plan' which is often associated with an independence between the structural support elements and the outer and inner partitions. *It suggests that it is not only a dissociation between the elements of the former and the elements of the latter free plan is concerned with, but also with a dissociation between their organising properties*

Looking at the relation between the grid lines of the two grids analysis suggested that at stage two not every physical grid line coincides with a structural line. At stage three an one to one correspondence is

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35 A. Colquhoun, 'Modernity and the Classical Tradition', The MIT Press, Cambridge, Massachusetts and London, 1989, p. 125-133.

constructed in the sense that almost every line generated by the extension of a boundary coincides with a line of the structural grid.

Thus, whereas the logical systems that organise the physical and the structural grid are different from each other, the lines that define their elements at the final stage coincide. *This observation also extends the definition of the free plan often considered as consisting of independent elements. Analysis reveals that the liberation of the partitions from the structural elements is only physical in character. The lines connecting the elements of these systems are never independent from each other.*

Analysis also showed that the majority of the plans are characterised by a low I/O line index[36], (TL 4.2, p. 291). This shows that the positions of the internal partitions on the plans are not determined by overall restrictions emerging from the first stage, i.e. from the external articulation. It also suggests that there is no intention to achieve physically defined geometrical grids by systematic alignments of the physical elements of the interior along the grid lines generated by the elements of the exterior.

Thus, the grids of the external and the internal configuration are treated as independent systems. Therefore, it is not only an independence of their organisational logic these plans achieve but also a physical independence amongst the elements of the former and those of the latter.

- **The relationship between the shape and the grid properties**

Analysis showed that at stage one a dissociation is created between the asymmetrical organisation of shapes and the symmetrical organisation of the grid lines. At the following stages the transformation of grids from a symmetrical to an asymmetrical organisation shows a constant tendency to negate symmetry at the level of both properties. However, a contrast between shape irregularity and grid regularity is sustained by the structural grid in both stages two and three.

Besides, because of the lack of any consistent pattern of development of symmetry/ asymmetry along the analytic stages there is no consistent pattern of association/dissociation between the shape and the grid properties. Thus, at the first and second floor of LH1, the ground floor of LH2 and the first and second floor of LH4 a dissociation is constructed between the asymmetrical organisation of the shapes and the symmetrical or 'just about' symmetrical organisation of the grids at length, (TL 4.1, p. 291). Besides, at the second floor of LH1 and the ground floor of LH4 a dissociation is constructed between the two types of properties based on a contrast between the asymmetrical arrangement of shapes and the 'just about' symmetrical organisation of grids on the LR axis, (TL 4.1, LR, p. 291).

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36 The only exception is the third floor of LH1 at stage two that has an I/O line index 0.71, (TL 4.3, p. 291).

Finally, the same dissociation takes place at stage three at the first and third floor of LH1, the ground floor of LH2 and the second and third floor of LH4 with respect to the BF axis, (TL 4.1, p. 291). However, regardless of these dissociations a general tendency can be observed that favours the development of symmetry at the level of the least observable properties, i.e. the properties of the geometrical grids.

- **GEOMETRICAL PROPERTIES AND INTELLIGIBILITY**

The lack of overall symmetry of the shape organisation disturbs a clear and straightforward reading of the plans based on the recognition of a single geometrical rule that organises all shapes.

Besides, in the cases in which there is no symmetry characterising the grid organisation a clear and straightforward understanding of the geometrical logic of the grid is not possible either. This is because there is no identification of a single rule that gathers the elements around the co-ordinating powers of a single geometrical axis and a single geometrical bay.

In the cases in which symmetry/asymmetry alternate along the sequences the understanding of the geometrical ordering of the plans is also disturbed by the simultaneous application and negation of an overall organising principle.

The simultaneous coincidence and independence between the structural and the physical grid based on a simultaneous coincidence and differentiation of their organising rules creates a multileveled organisation. This organisation in which the grid elements merge into a single geometrical configuration while their properties belong to two different organisational principles[37], communicates its logic with great difficulty. It seems to demand close scrutiny in which each grid has to be drawn in a separate piece of paper. It is only then that their profound differences are observed.

Finally, the independence constructed amongst the lines of the external and the lines of the external organisation leads to a grid that lacks physical definition. 'Buried' under the undulating walls and the asymmetrical arrangements of the interpenetrating shapes this grid resists to be deciphered. One would have to draw the extensions of lines on paper to study its organisation. However, even then the symbiosis of symmetry and asymmetry and the lack of consistency in their occurrence along the analytic stages make this decipherment an extensive and difficult enterprise in which no single interpretation is possible.

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37 As mentioned above in certain case the regular intervals of the structural grid contrast the irregular intervals of the geometrical grid. In other cases the equal spacing of the former contrast the alternation of wide and narrow intervals of the latter.

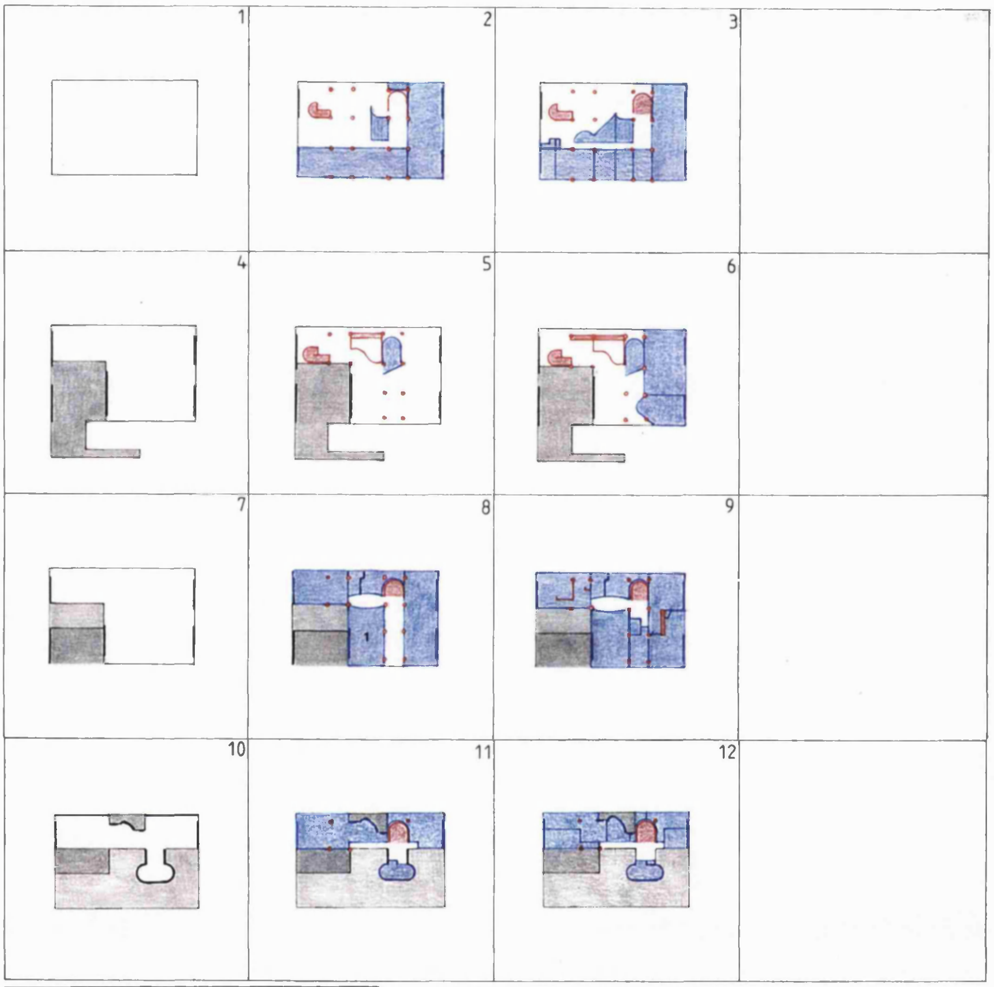


Table **LH1 4.1**
**Shape Geometrical Properties**

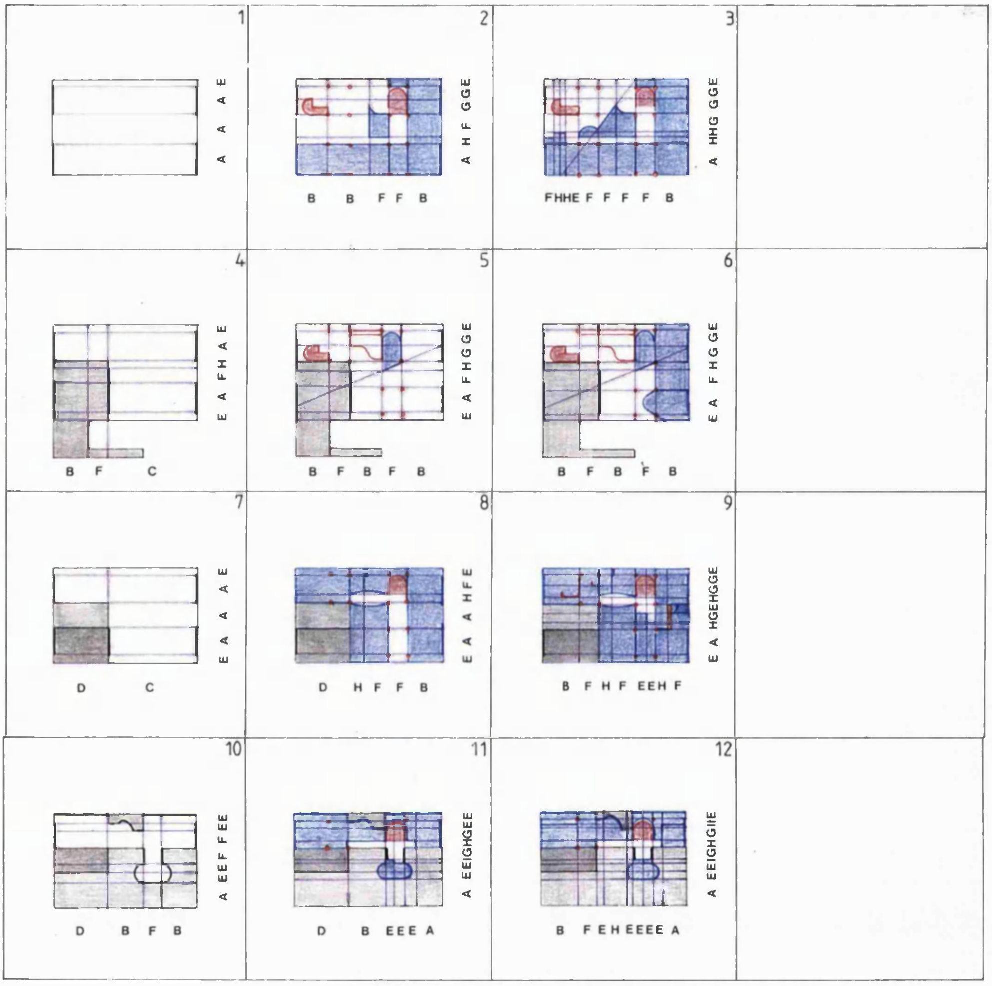


Table LH1 4.2
Grid Geometrical Properties

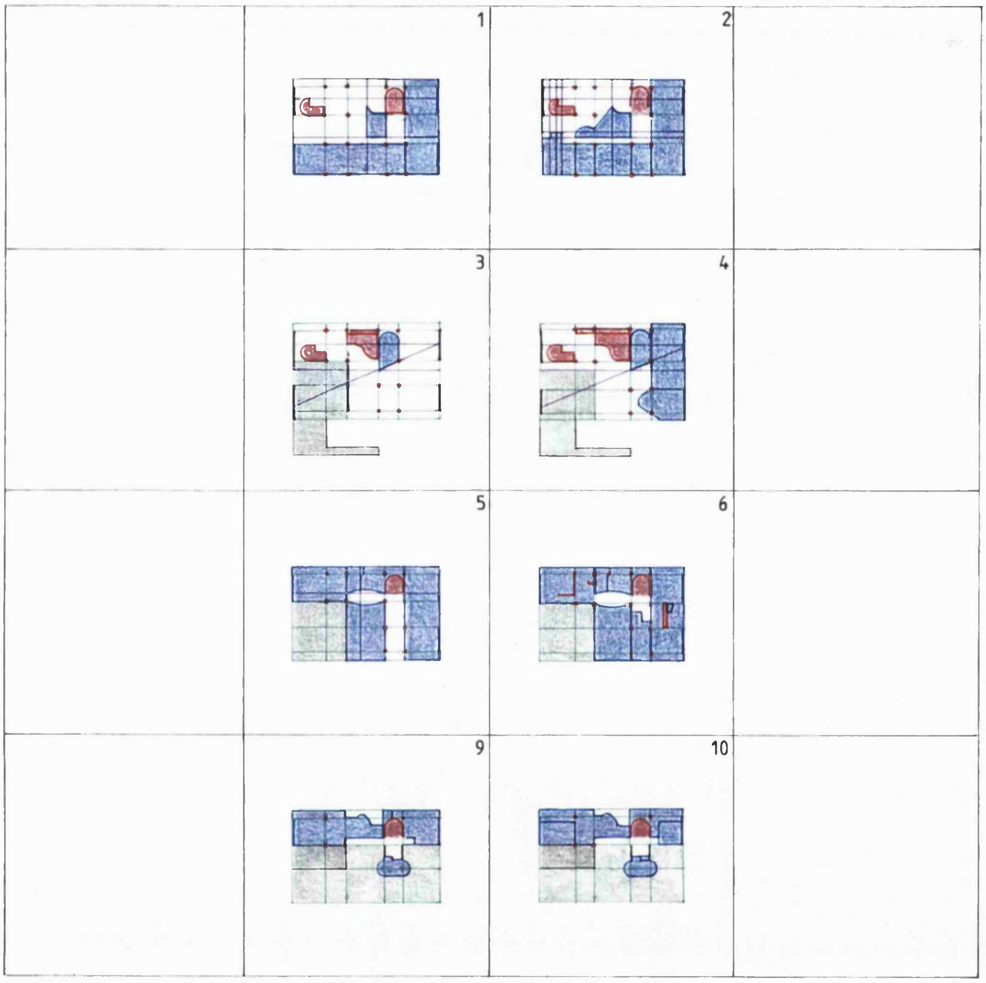


Table LH1 4.3
**Structural Grid Geometrical Properties**

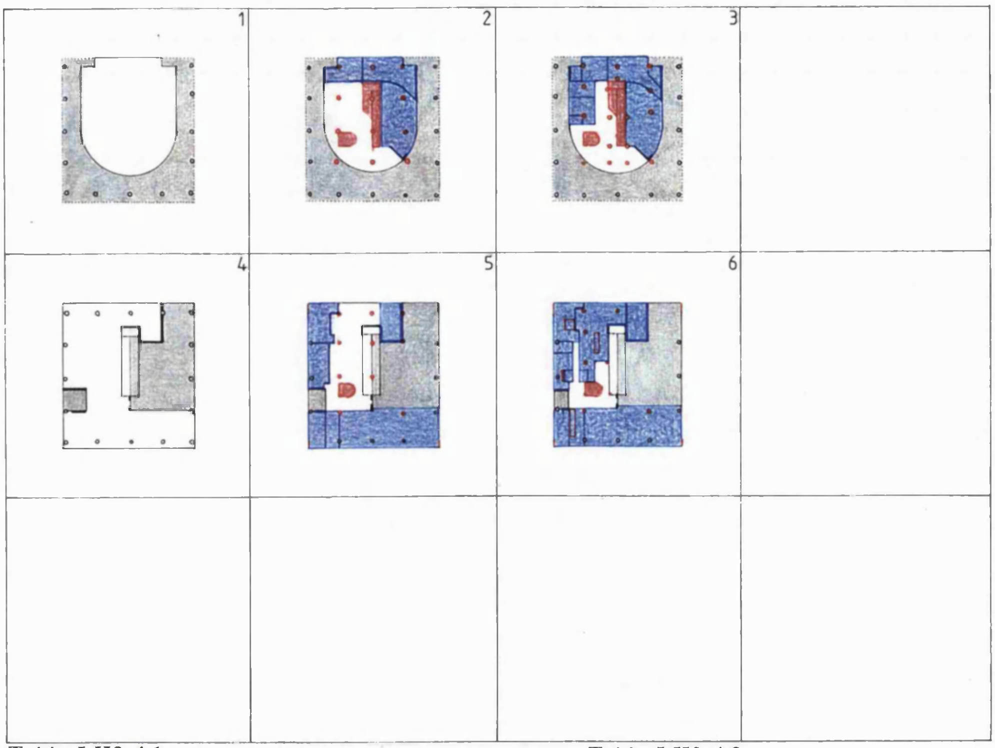


Table **LH2 4.1**
**Shape Geometrical Properties**

Table **LH2 4.2**
**Grid Geometrical Properties**

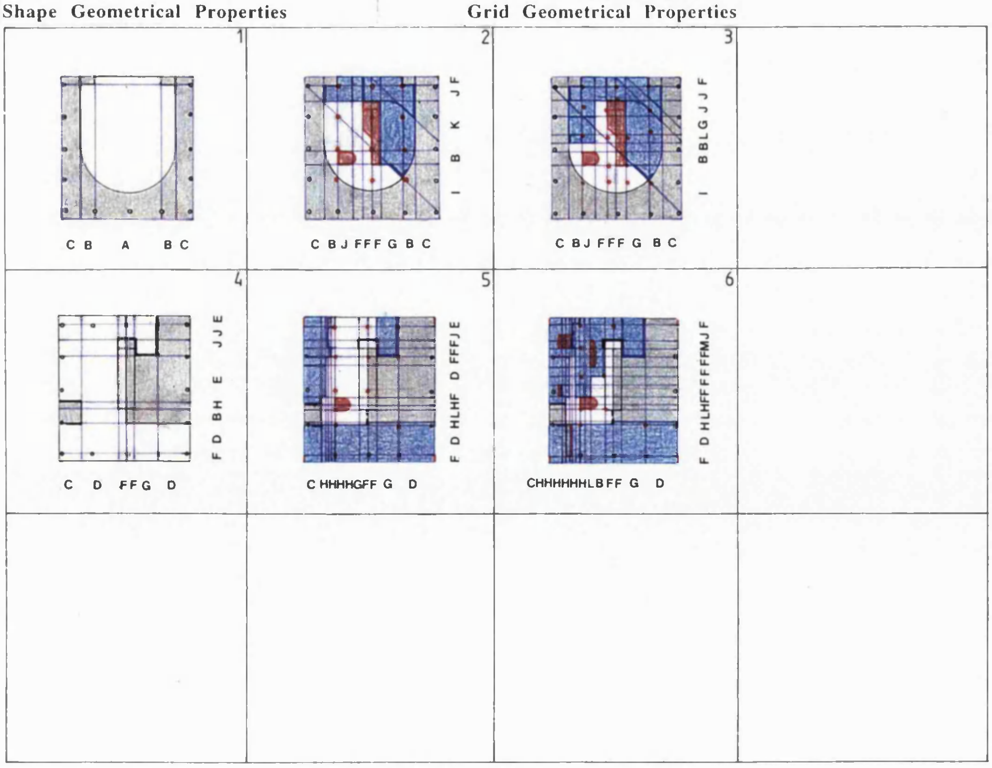

Table LH2 4.3
**Structural Grid Geometrical Properties**

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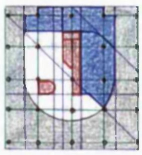
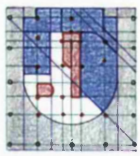
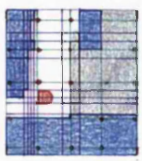
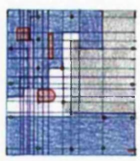
|---|---|---|---|
| | 1  | 2  | |
| | 3  | 4  | |
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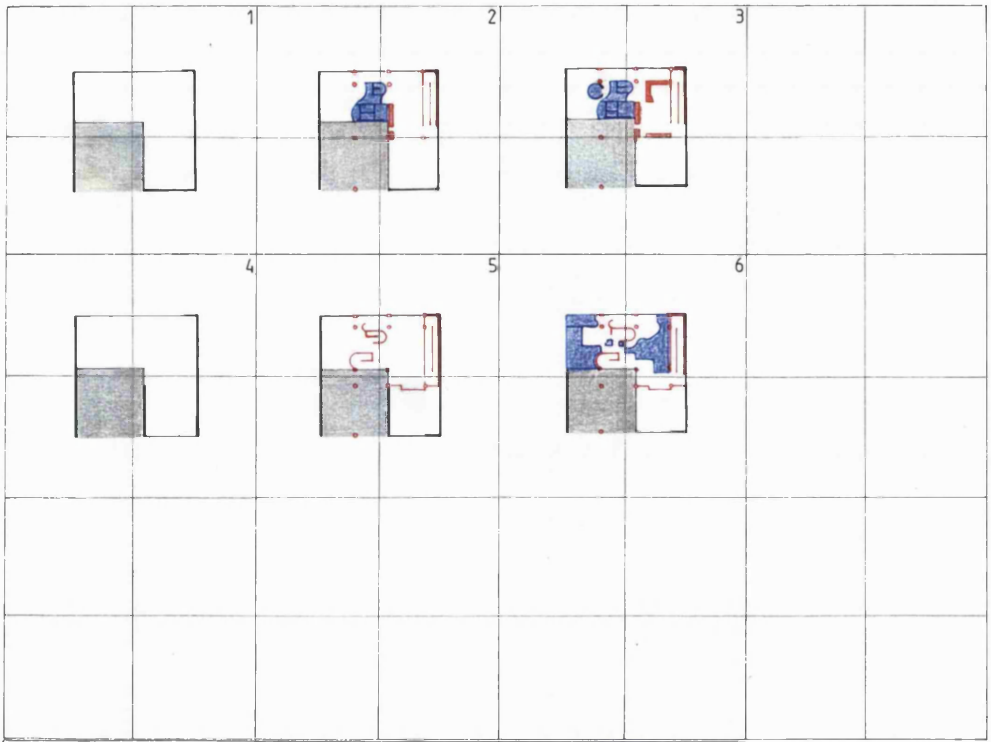



Table LH3 4.1
Shape Geometrical Properties

Table LH3 4.2
Grid Geometrical Properties

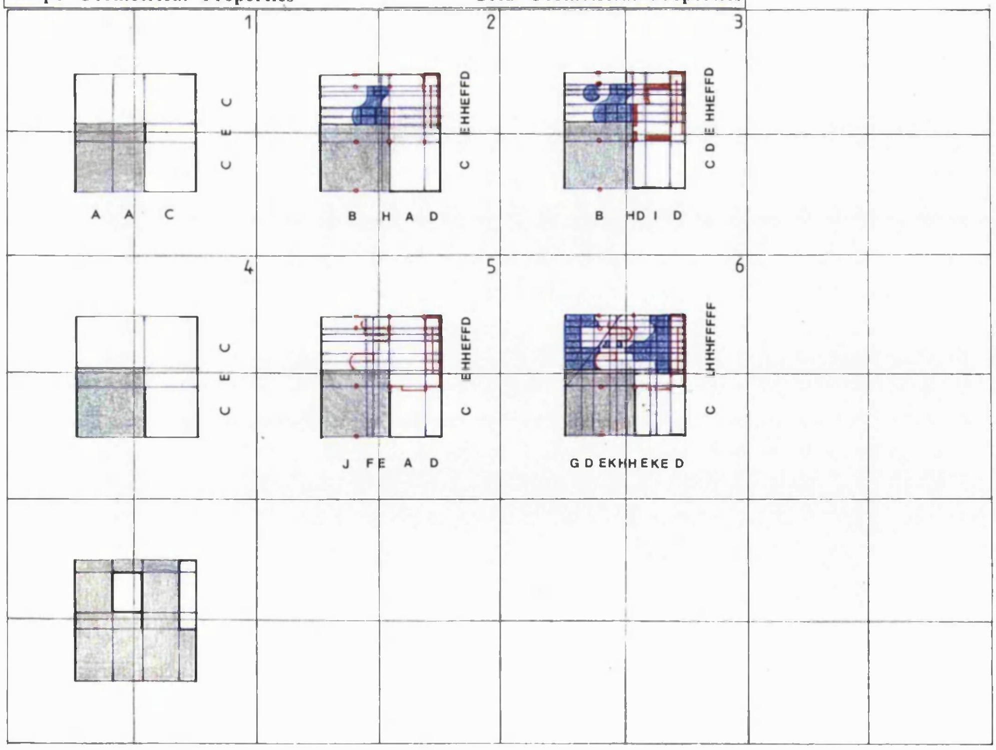
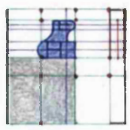
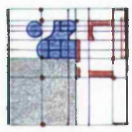
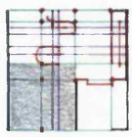
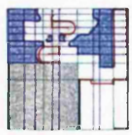


Table **LH3 4.3**
**Structural Grid Geometrical Properties**

| | | | |
|---|---|---|---|
| | 1  | 2  | |
| | 3  | 4  | |
| | | | |

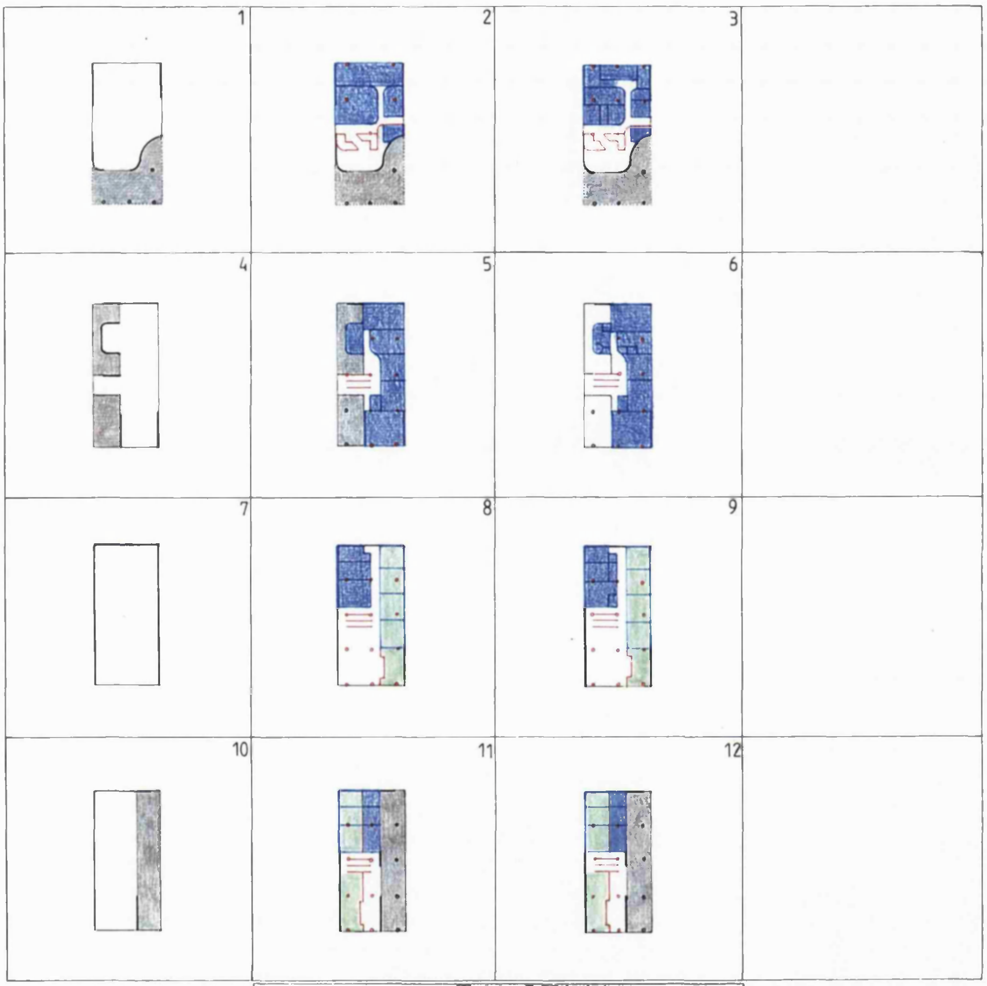



Table LH4 4.1
Shape Geometrical Properties

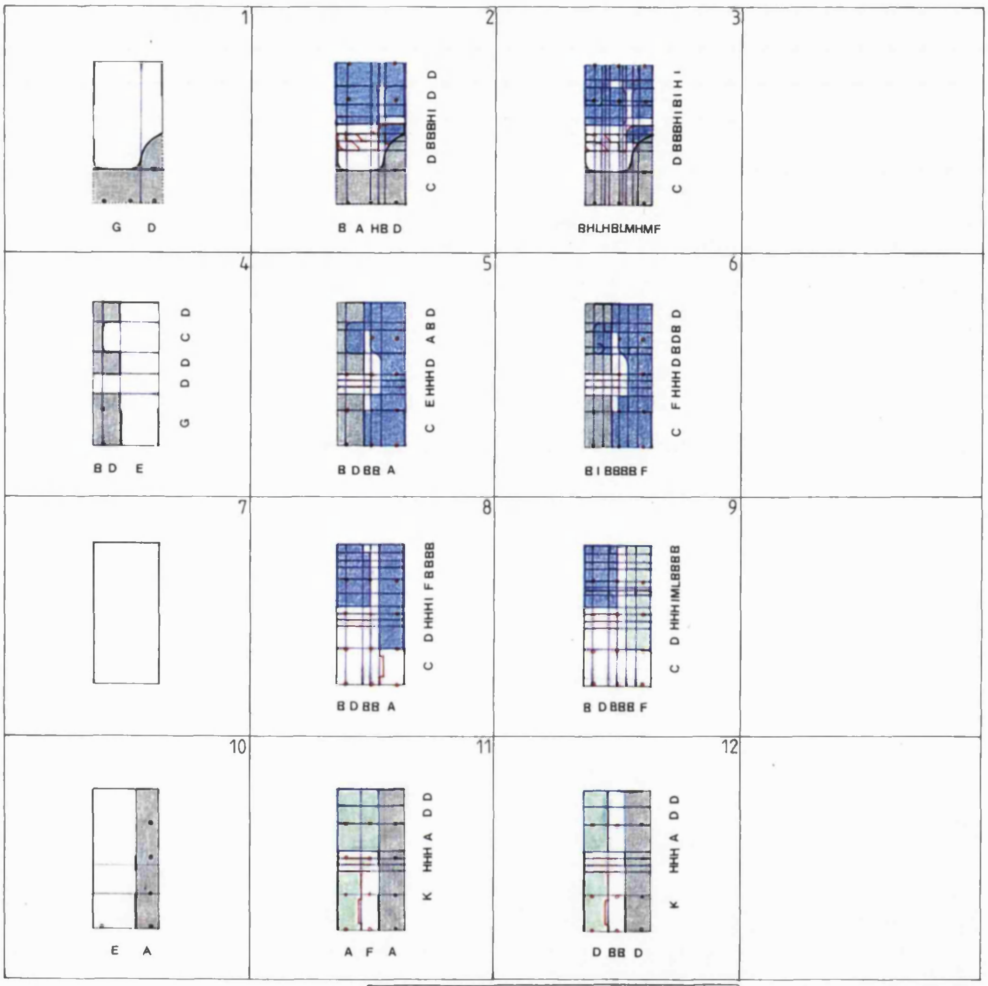



Table **LH4 4.2**
**Grid Geometrical Properties**

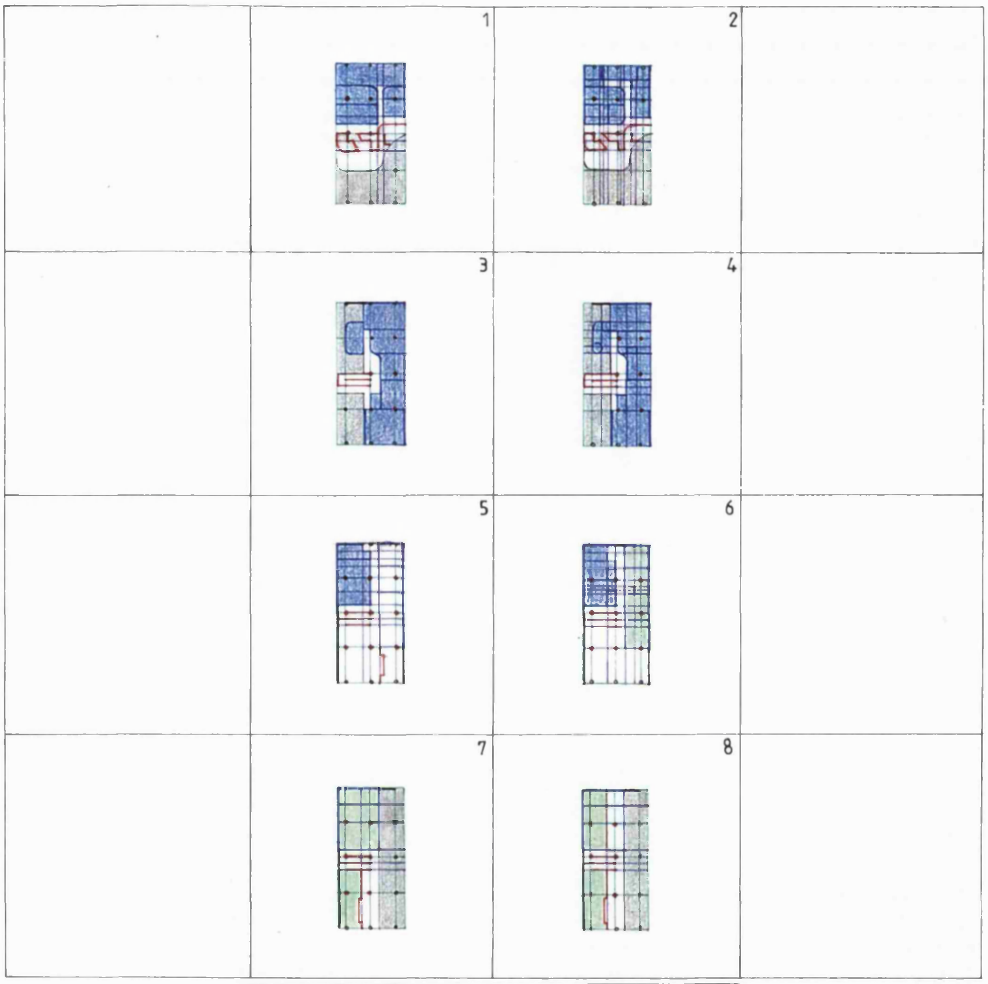



Table LH1 4.3
Structural Grid Geometrical Properties

| | LH1 | | | LH2 | | | LH3 | | | LH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 1 | 0.50 | 0.63 | 1 | 0.83 | 0.79 | 0.50 | 0.40 | 0.50 | 0.66 | 0.50 | 0.45 |
| 1ST | 0.50 | 0.85 | 0.85 | 0.71 | 0.63 | 0.50 | 0.66 | 0.66 | 0.66 | 0.50 | 0.83 | 0.62 |
| 2ND | 0.66 | 0.66 | 0.66 | | | | | | | 1 | 0.83 | 0.71 |
| 3RD | 0.80 | 0.57 | 0.80 | | | | | | | 0.66 | 1 | 1 |

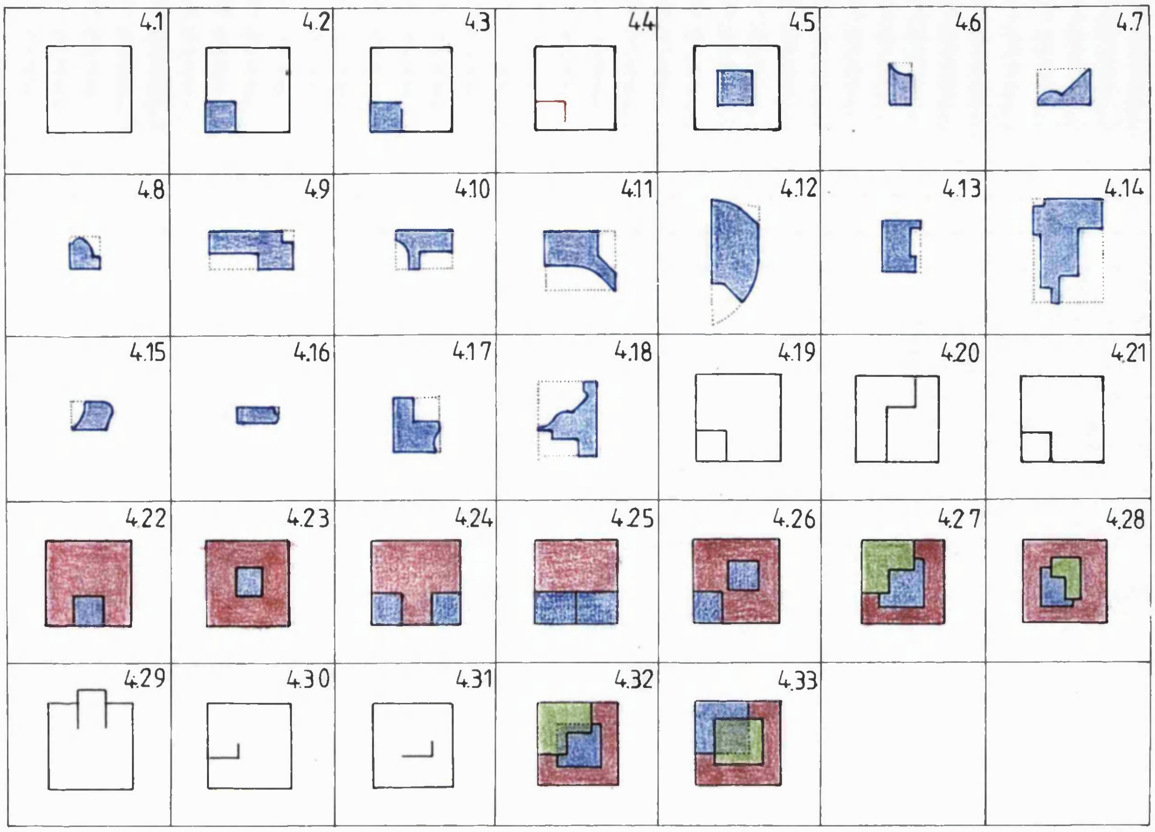
Table L 4.1
**SYMMETRY GRID INDEX, (BF)** - No of geom lines synm on BF axis/Total no of lines

| | LH1 | | | LH2 | | | LH3 | | | LH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 0.80 | 0.57 | 0.44 | 0.66 | 0.37 | 0.33 | 1 | 0.44 | 0.44 | 0.66 | 0.70 | 0.58 |
| 1ST | 0.85 | 0.66 | 0.66 | 0.66 | 0.30 | 0.66 | 1 | 0.55 | 0.53 | 0.50 | 0.30 | 0.36 |
| 2ND | 1 | 0.85 | 0.60 | | | | | | | 1 | 0.58 | 0.50 |
| 3RD | 0.50 | 0.40 | 0.36 | | | | | | | 0.50 | 0.37 | 0.37 |

Table L 4.2
**SYMMETRY GRID INDEX, (LR)** - No of geom lines synm on LR axis/Total no of lines

| | LH1 | | | LH2 | | | LH3 | | | LH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | | 0.40 | 0.21 | | 0.33 | 0.35 | | 0.36 | 0.30 | | 0.21 | 0.15 |
| 1ST | | 0.25 | 0.36 | | 0.50 | 0.53 | | 0.30 | 0.20 | | 0.60 | 0.50 |
| 2ND | | 0.66 | 0.35 | | | | | | | | 0.17 | 0.15 |
| 3RD | | 0.71 | 0.63 | | | | | | | | 0.10 | 0.30 |

Table L 4.3
**INSIDE/OUTSIDE LINE INDEX** - No of geom lines of internal and external elements/Total no of lines


4.1
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4.9
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4.33

**T4.1**

- **COMPARISON BETWEEN BOTTA AND LE CORBUSIER**

- **THE PATTERNS OF THE TRANSFORMATION PROCESS**

At the beginning of this chapter a general discussion of the work of these architects lead to the suggestion that Botta's houses are easily grasped as simple physical and geometrical structures. On the other hand, Le Corbusier's houses are difficult to understand due to their complex physical and geometrical articulation.

However, although a first description identified strong differences, the analytic examination revealed certain similarities. These refer to the operations they use in the transformation of their plans as well as to the order in which these operations occur along the analytic stages.

- **Operations and their order of occurrence**

In Botta nine out of twelve floors, (9/12) are transformed by superimposition and four floors, (4/12), by addition/extension. Similarly, Le Corbusier uses superimposition in eleven floors, (11/12) and addition/extension in five floors, 5/12). Superimposition and addition/extension are used in both stages two and three. At stage two equal emphasis is put on both operations[38], (TBH-S, TBH-S/E, TBH-S/A/E, p. 245, TLH-S, TLH-E, TLH-S/E/A, p. 269). Finally, at stage three superimposition is favoured over addition/extension .

Thus, both architects use superimposition, addition and extension. At stage two they start transformation by superimposing volumetric components along the periphery of the volume, by extending certain surfaces or by adding elements on the plan. At stage three they continue applying these operations. However, addition is not extensively used at this stage. It is mainly associated with a larger scale articulation occurring at stage two rather than with a smaller scale characterising the last stage.

*Therefore, both Botta and Le Corbusier adopt a consistent pattern of transformation that relates certain stages to certain operations. Analysis also showed that they both associate certain stages with certain shapes as well as with certain ways in which these shapes are combined. Thus, they seem to follow a specific design process in the articulation of the plans.*

Nevertheless, regardless of these similarities they approach transformation in a different way. Thus, Botta preserves the properties of the block in both stages two and three, whereas Le Corbusier is not consistent in preserving or denying these properties. The same argument was put forward in the analysis of the volume. It was suggested that Botta retains the physical and geometrical principles of the largest

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38 However, addition at this stage is slightly more emphasised by both architects. Thus, it occurs in all twelve floors, whereas superimposition takes place in ten out of twelve floors, (10/12).

volumetric component throughout the stages. Le Corbusier distinguishes between stages in which he preserves and stages in which he suspends these principles. Volumetric and Plan Analysis show that they both maintain a consistent approach to transformation from the scale of the articulation of the volume to the scale of the articulation of the plan.

- **THE RELATIONAL LOGIC OF TRANSFORMATIONS**

- **The types of shapes**

The different approach to transformation these architects have is associated with a difference in the shapes they use and in the ways in which they combine them. Each of them superimposes different shapes on his plans. Botta superimposes a rectangle or a planar L. Le Corbusier superimposes either simple shapes, like the ones mentioned above, or more complicated shapes like the ones shown in fig. 4.6-4.18, (p. 292).

The ways these architects place the superimposed components on the plans is also different. Botta places the majority of these elements at the corners of the block[39]. Le Corbusier places his superimposed elements either at these corners or at the corners of the L or both at the corners and the centre of the plan[40]. In Botta the superimposed elements share at least two of their defining surfaces with the surfaces of the block. In Le Corbusier they share either two or one or none of their defining elements with the outer surfaces.

Thus, at the ground, first and second floor of LH1, (TLH1 4.1, fig. 2, 3, 5, 6, 9, p. 281), at the first floor of LH2, (TLH2 4.1, fig. 6, 284), the ground and first floor of LH3, (TLH3 4.1, fig. 3, 5, 6, p. 286), and all floors of LH4, (TLH4 4.1, fig. 2-12, p. 288), the superimposed shapes occupy both the periphery and the centre of the plan. At the third floor of LH1, (TLH1 4.1, fig. 11, 12, p. 281), the ground floor of LH2, (TLH2 4.1, fig. 2, 3, p. 284), they have peripheral locations.

These considerations suggest that Botta is consistent regarding the shapes used, their positions in the interior and the ways they relate to the elements of the external articulation. On the other hand, Le Corbusier is not characterised by such consistency. The shapes of the interior, their position and the

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39 Bathroom 1 at the second floor of LH1, the curvilinear shape at the centre of the ground floor of LH2 and the small rectangular shapes at the back of the first floor of LH3 are exceptions sharing either one or none of their surfaces with the outer surfaces.

40 For example, Madame Savoie's bedroom superimposed on the first floor of LH2 extends from the central back part to the centre of the plan sharing only one surface with the surfaces of the largest volumetric rectangle, (TLH2 4.1, fig. 6). Further, the cylindrical shape and one of the two the curvilinear shapes superimposed on the ground floor of LH3 occupy the centre of the plan sharing none of their defining elements with the outer surfaces, (TLH3 4.1, fig. 3).

number of surfaces they share with the surfaces of the large volumetric components vary from one house to another.

Nevertheless, regardless of their complexity and of the differences in their physical appearance, Le Corbusier's shapes have a common characteristic: They result from the subtraction of one or more planar Ls from a rectangle. They all register back to a simpler shape belonging to a higher level of abstraction. Besides, regardless of the absence of a recurrent combination of shapes that specifies a fixed position on the plan, a general rule is used according to which the majority of the shapes share at least one defining surface with the outer surfaces.

Therefore, Botta has a narrow and fixed repertory of shapes and combinations. Le Corbusier has a broader vocabulary of shapes and a flexible vocabulary of combinations. Recurrent use of specific shapes in a specific combination in Botta results in interiors that look almost similar to one another. In Le Corbusier a wider variety of shapes and combinations result in interiors that look different from each other.

*Thus, Botta emphasises clarity of shape depiction and shape combination. On the other hand, Le Corbusier puts the emphasis on the impossibility to isolate clear geometrical shapes.*

Elimination of variety, simplicity of the recurring shapes and explicitness of their combinations in Botta emphasises the total arrangement of shapes and forms rather than the individual components. Variety, complexity of shape configuration and implicit shape combinations in Le Corbusier create a contrast between the local scale and the overall pattern. Shapes become prominent directing attention from the global organisation to themselves.

Botta shapes are understood almost at a glance. Le Corbusier's jig-saw shaped elements are not easily grasped. In Botta the viewer capturing a simplicity of shape configuration and shape combination, seeks the rules that hold shapes together. In Le Corbusier, one absorbed by the intricate shape articulation cannot immediately direct his attention to the overall pattern.

- **RULES OF COMBINATIONS**

- **Physical properties**

- **Stage one - The material definition of the largest volumetric components**

As it was mentioned earlier the organisation of the plans is seen as an interaction amongst the elements of the interior and those of the exterior. Analysis of physical properties looked at the physical definition of these elements as a factor influencing their physical recognisability. It also looked at how the material used to define their contour affects this recognisability further.

At stage one the material definition of surfaces in Botta creates a distinction between the block, the U and the void. Whereas the block is defined by opaque surfaces, the U and the void are defined by both opaque and transparent ones. Whereas the block retains a uniform solid contour, the rest of the components are broken into volumetric and planar elements. In this way, the distribution of material preserves the physical properties of the initial solid and its hierarchical distinction in the configuration.

In Le Corbusier the block and the secondary elements are defined by both solid and glazed surfaces. The distribution of material decomposes the corners of these elements into volumetric and planar constituents challenging their volumetric character. It also challenges the hierarchical distinctions amongst them creating a network of interacting planes, rather than a classification into identifiable categories of shapes with different degrees of global significance.

- **Stages two and three - Superimposition, addition/extension**

- **The relationship between the elements of the external and the internal articulation**

At the following stages Botta preserves also the identity of the block. Le Corbusier extends the decomposition of the block into the interior by analysing the superimposed elements into volumetric and planar components.

In Botta a decomposition of the superimposed shapes occurring at the point of intersection of their surfaces with the outer boundary enables the latter to complete the block. Besides, a distinction between thick and thin surfaces articulates a distinction between the block and the internal shapes. *The surfaces of the block on plan form a clear rectangle that frames a composition of shapes and lines.*

In Le Corbusier there is also a distinction between thick and thin surfaces expressing a distinction between the initial solid and the superimposed elements. Besides, some of these elements are also decomposed into planes and volumetric corners. However, this decomposition interacts with the decomposition of the elements of the volumetric articulation in a way that the hierarchical distinction between the large and the small scale components is not clarified. *On the contrary, these elements are analysed into a gridded pattern of shapes, rectilinear, curved and oblique lines on the plans.*

Thus, the decomposition of the small scale elements in Botta serves the purposes of the large scale. In Le Corbusier it interacts with the decomposition of the physical elements characterising the external articulation.

However, Le Corbusier creates a distinction between the outer boundary and the internal shapes. This is based on the thin lines representing the transparent outer surfaces as opposed to the solid lines representing the internal ones. It is also based on the distinction between thick solid lines expressing the outer boundary and thin solid lines expressing the internal partitions. Nevertheless, the outer surfaces of the volume are never defined by a single type of material. Thus, the material definition of the surfaces of the block does not create an homogenous frame that can be distinguished as a closed shape.

- **The relationship amongst the elements of the internal articulation**
  Analysis suggested that Botta superimposes simple shapes on the plans, whereas Le Corbusier uses both simple and complicated ones. Further, in Botta shapes are arranged on the corners of the volume sharing either a straight surface or none of their surfaces. On the other hand, in Le Corbusier they interlock sharing a jig-saw shaped surface. Thus, whereas Botta's shapes are clearly distinguished from each other, Le Corbusier's are fastened together in dispense of their clarity as individual geometrical entities.

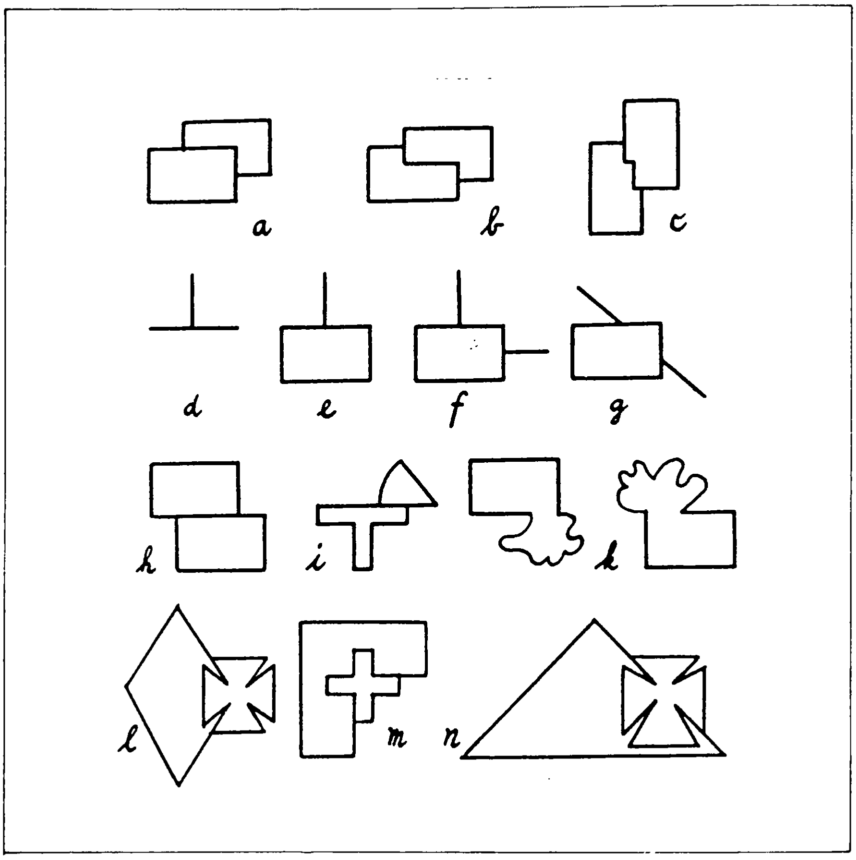
In Botta the simplicity and clarity of the superimposed shapes enhances the recognisability of the block enabling the large scale to prevail. In Le Corbusier the interlocking shapes increase the complexity resulting from the decomposition of the large and the small scale elements.

Volumetric analysis suggested that interlock creates simultaneous readings disturbing a single interpretation of the configuration. The difficulty to distinguish the elements of the volumetric articulation from the elements of the internal articulation in Le Corbusier is, thus, increased by a complex and multifaceted levels of interaction amongst the latter.

- **Two dimensional representation and the variable of space**
  Analysis has considered plans as two representations expressing the arrangement of shapes on a two dimensional plane. However, plans work in a pictorial way also expressing a three dimensional extension of space on a flat plane. At this section analysis examines how this expression is possible as well as how it is affected by the physical and geometrical properties of the plan.

At this point a parenthesis is opened to explain the ways the operations of superimposition, addition and extension affect the representation of space on flat projection.

**4**

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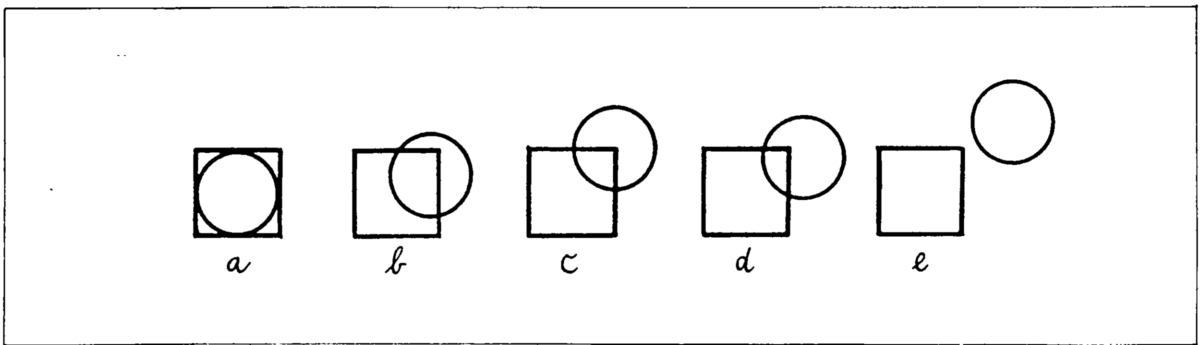


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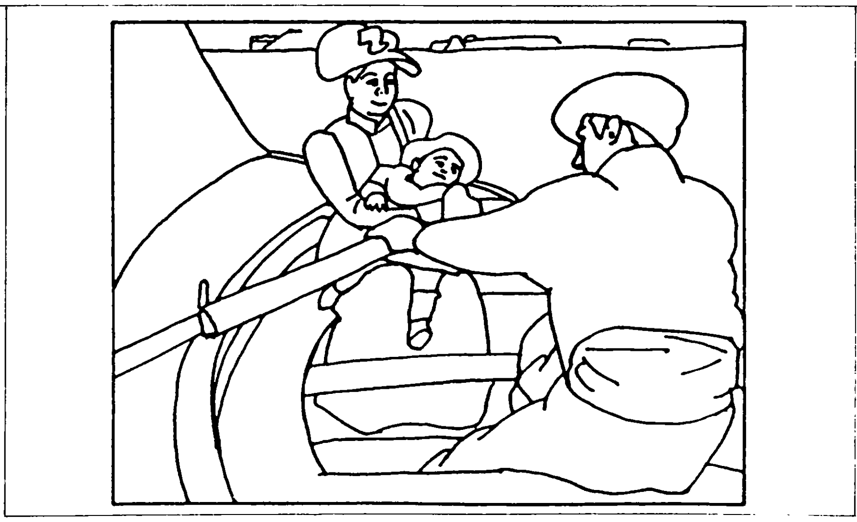

(35)

Regardless of which operation is used in a transformation process, the elements introduced in a configuration create the same effects in terms of their relation to an initial rectangle. This refers to the *interruption* of its space or the *interruption* of both its space and boundaries they produce[41]. Thus, all three operations could be seen as different means of creating *interruption.*

In fig. 4.21-4.31, (p. 292), two different types of interruption created by each operation are presented. Looking at these figures it seems that regardless of the type of operation, regardless of whether the elements interrupting a space read as closed shapes or as open lines and regardless of the ways the large rectangle relates to the superimposed, added or extended components, the two dimensional arrangement incorporates the variable of overlap.

The effect of overlap is to assign a location to each of the shapes in a way that one lies in front of the other. R. Arnheim points out that when two shapes overlap the shape which is interrupted takes the back position[42], (illustration 4.33). This way one is interpreted as figure and the other as ground.

Fig. 4.21-4.31, (p. 292), present two categories of interrupted shape. One refers to the interruption of a rectangle's space by one or two shapes or lines, fig. 4.23, 4.28, 4.31, (p. 292), whereas the other refers to the interruption of both its space and boundaries, fig. 4.21, 4.22, 4.24, 4.25-4.27, 4.29, 4.30, (p. 292). Besides, figures 4.24-4.28, (p. 292), present two different ways in which the superimposed shapes relate to each other. In figures 4.24, 4.25, 4.26, (p. 292) the superimposed shapes do not interrupt each other. On the other hand, in figures 4.27, 4.28, (p. 292), the shapes interlock interrupting each other's space and boundaries.

In figures 4.24, 4.25, 4.26, (p. 292), two planes are only implied in depth. These are the plane of the initial rectangle and the plane of the superimposed shapes. In figures 4.27, 4.28, (p. 292), there is a suggestion of three planes. This is because in the former the two superimposed shapes do not overlap, whereas in the latter they do taking, thus, different positions in depth[43].

Thus, the notion of two interlocking shapes creates also illusion of depth, (fig. 4.27, 4.28, p. 292). This is because each shape can be 'seen' as continuing behind the other one. However, both contours can be

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41 In this chapter space is seen as it features in two dimensional representation rather than in reality. Thus, by space the area bounded by the defining lines of the initial rectangle is meant.

42 R Arnheim, 'Art and Visual Perception', A Psychology of the Creative Eye', University of California Press, Berkeley, Los Angeles, London, 1974, p. 249.

43 Arnheim suggests that in a configuration of two overlapping shapes space is 'seen' when the three dimensional reading is 'structurally simpler than the two dimensional one. Thus, in illustration the circle and the rectangle of the second figure 'tend to detach themselves in depth because this divorce frees them from the stressful combination that exists in the flat projection'. Ibid., p. 247.

perceived as interrupted, (fig. 4.32, 4.33, p. 292). Attention shifts from one situation to the other seeing one shape as 'figure' and the other as 'ground' and vice versa. Thus, the interlock relationship of the superimposed shapes in fig. 4.27, 4.28, (p. 292), creates two planes that constantly fluctuate back and forth.

Analysis suggested that the superimposed shapes of Botta do not overlap. Thus, they enter into relations that are represented by figures 4.24-4.26, (p. 292). On the other hand, the interlock relations created amongst certain superimposed shapes in Le Corbusier are expressed by figures 4.27, 4.28, (p. 292).

Gombrich suggests that overlap is known since the antiquity as a principal device in indicating spatial recession in pictorial representation[44]. S Barnet suggests also that in formal analysis of painting the ability of the artist to convey depth should be tested by a list of parameters one of which is overlap[45]. R. Arnheim, analysing the image in illustration 4.35, (p. 298), suggests that the effect of overlap 'assigns each object its place in the scale of spatial locations from the man and his arm to the oar of the child, the mother, the stern of the boat, the water and the coastline' [46].

The effects of overlap are used in other areas of art also concerned with the representation of space on a flat surface like in film art. D Bordwell and K Thomson suggest that overlap is a 'depth cue' enabling the viewer to construct a three dimensional world on the flat plane of the cinema screen[47]. The authors propose that previous experience of space in the real three dimensional world interferes with the image prompting the viewer to 'see' a three dimensional space extending beyond the flat screen.

The two dimensional representation of buildings being about overlapping shapes created by the operations of superimposition, addition and extension also incorporates and expresses the variable of depth. This has been already suggested by various authors who based on Gestalt laws read windows as figures against the continuous ground of a wall or bounded spaces as figures against a flowing circulation space[48].

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44 'In his description of a real or imaginary painting Philostratus commends the trick of the artist who surrounds the walls of Thebes with armed men, 'so that some men are seen in full figure, others with the legs hidden, others from the waist up, then only the busts of some, heads only, helmets only, and finally just spearpoints. All that , my boy, is analogy, for the eyes must be deceived as they travel back along with the relevant zones of the picture', E. H. Gombrich, 'Art and Illusion, A Study in the Psychology of Pictorial Representation', Phaidon, Press Limited 1992, p. 176.

45 S Barnet, 'A short Guide to Writing about Art', Editorship by s Barnet, M Sturbs, p. 38.

46 R Arnheim, 'Art and Visual Perception', A Psychology of the Creative Eye', University of California Press, Berkeley, Los Angeles, London, 1974, p. 251.

47 D Bordwell, K Thomson 'Film Art, An Introduction', Copyright by Mc Draw-Hill, 1993, p. 166.

48 W. Mitchell, 'The Logic of Architecture, Design, Computation and Cognition', The MIT Press, p. 4.

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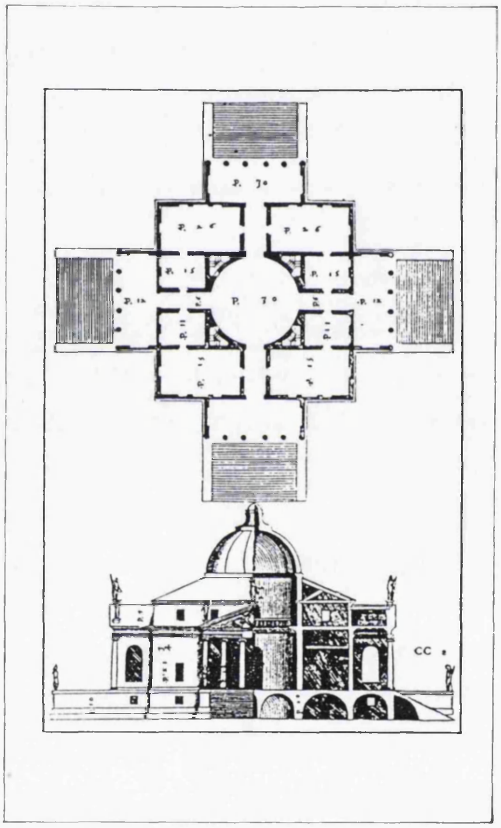

36

R. Arnheim suggests that a series of investigations on the figure-ground phenomenon are mostly preoccupied with defining which shape lies in front. However, according to him the situation is often more ambiguous and shifting readings alter our perception of the location of each shape[49].

However, regardless of these ambiguities Arnheim uses figure/ground readings to explain the ways the plan of Villa Rotonda communicates its spatial organisation[50], (illustration 4.36). '...On the plan the corridors are nothing more than the background separating the four blocks of rooms from one another'. Thus, he seems to suggests that the figure-ground relationship communicates a spatial organisation based on bounded spaces and a background of fluid space that connects them together.

The aims of this analysis go beyond an extensive investigation of the parameters determining the location of shapes in depth. They concentrate on the ways figure-ground relationships are established on the plans of these architects.

Besides, based on Arnheim's proposition regarding the ways figure-ground relations communicate a spatial organisation in Villa Rotonda this analysis asks: *Looking at Botta's and Le Corbusier's plans is there something in the ways the shapes relate to each other in depth that communicates a spatial organisation?*

Going back to the physical properties of these buildings the following fundamental differences regarding the ways the shapes form planes in depth in Botta's and Le Corbusier's plans present themselves. These are:

- Botta establishes a clearly bounded rectangle against which the rest of the components are placed. On the other hand, Le Corbusier decomposing this rectangle into transparent or opaque planes, i.e. thick or thin lines, creates a composition of lines rather than a clearly defined geometrical shape.

  The continuity of the outer boundary in Botta *constructs a pictorial surface, a backdrop against which the rest of the components place themselves.* The lack of uniformly bounded shape in Le Corbusier *undermines the strength of the initial rectangle to act as a pictorial landscape.*

- Each of the superimposed elements in Botta occupy one of the four corners of the rectangle never interrupting the space and boundaries of each other. On the other hand, certain components in Le Corbusier overlap and interlock interrupting each other's space and defining surfaces.

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49 R Arnheim, ibid., p. 228.

50 R. Arnheim, 'The Power of the Centre, A study of Composition in the Visual Arts', University of California Press, Berkeley, Los Angeles, London, 1988, p. 203.

Botta's internal shapes *extend rather on the same two dimensional plane than on the third dimension.* The overlap relations amongst the shapes of Le Corbusier *introduce overlaid planes extending in depth.* The interlock relations amongst them create *constant fluctuation of these planes in a way that they do not posses a clear location in spatial recession.*

- Both architects decompose certain superimposed shapes into a system of lines. These lines in Botta are distinguished from the sharp oneness of the bounded rectangle. In Le Corbusier they are fused with the network of lines into which the rectangle is analysed.

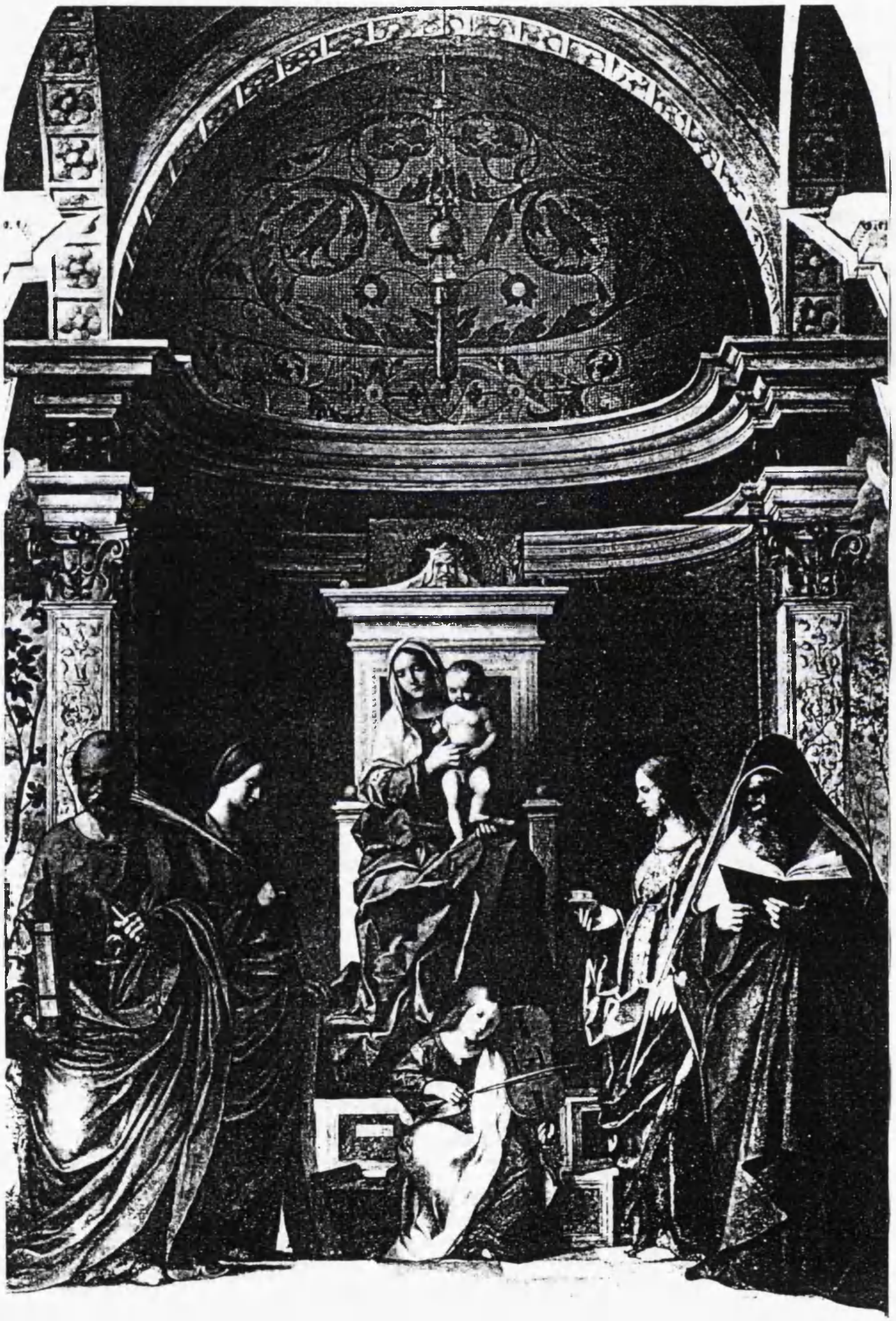
The clarity of the initial rectangle and the analysis of the superimposed shapes into lines in Botta *creates a plane of lines in front of a pictorial surface.* In Le Corbusier the analysis of both the rectangle and the superimposed shapes into a network of lines creates *a fusion of the pictorial plane and the plane of secondary elements.*

Thus, in Botta pictorial depth travels between the plane of the rectangle, the plane of the void, and the plane of the shapes and lines. The plane of the rectangle can be seen as the background. The plane of the drum and the void as the foreground, while the rest of the elements belong to an intermediate surface.

However, a second reading could be attributed to the configuration in which the void reads as a hole on the surface of the rectangle receding thus, to the background. The ambiguities of the figure-ground situation are, thus, at work in Botta's plans also. However, regardless of what location each plane occupies, spatial recession is suggested by *a tripartite composition of planes in depth.*

Le Corbusier's background plane is reduced to a network of interacting lines. The fusion of these lines with the lines of the superimposed shapes merges this plane with the foreground planes and *shrinks pictorial depth into the same surface.*

On the other hand, a series of intersecting, overlapping and interlocking components implies an *opposing situation of a spatial recession.* However, the advancing and receding movements of these components in depth establish a planar ambiguity. This ambiguity *dissolves once more the space between the planes locking them together in the picture plane. The overlapping planes are dragged back to their real condition, the condition of flatness.*



- **Architectural representation and pictorial space**

It turns out that Le Corbusier creates a highly complicated planar composition. Botta creates a composition that is stably built around three spatial planes. Figure-ground ambiguities in Botta shift the positions of the planes increasing the awareness of depth. In Le Corbusier, these ambiguities shrink depth clasping the planes together.

Although architectural and pictorial representation are different from each other, looking at the ways painting renders pictorial distance can demonstrate better the ways space steps out in Botta or shrinks back to the surface plane in Le Corbusier.

Similarities of a geometrical nature between Botta's plans and Giovanni Bellini's *Madonna with Saints*, (illustration 4.37), can establish a relationship amongst the figures in the picture and the geometrical shapes on the plan. The Madonna and the child, gaining their weight from their coincidence with the axis, evoke the void and the staircase drum. The groupings of the saints suggest the internal partitions, while the architectural background, clearly bounded by the ornamented pedestals and vault, evokes the sharpness of the bounded rectangle.

Bellini conceives his space as an organisation of three spatial locations. The curved wall behind the figures serves as a container for the depicted action and is, thus, location number one. The Madonna with the child are seated in front of this container occupying a second location. Finally, the groupings of the saints half framed by the pedestals of the niche, half overlapping these pedestals, advance to a third spatial location. Thus, the tripartite organisation of Botta's plans in depth is also analogous to the painting's organisation of pictorial space.

A comparison of pictorial space with the Corbusian plans cannot avoid reference to Cubism. It has been pointed out that the Cubists' preoccupation with interpenetrating planes is attributed to Le Corbusier's preoccupation with interpenetrating planar components. Colin Rowe recognises the advancing and receding planes of Parisian Cubism 'interpenetrating without optical destruction of each other' in a frontal and a roof plan analysis of Villa Stein[51].

Volumetric Analysis carried this proposition further by suggesting that the Cubist elimination of volume and mass is applied to the articulation of the volume. This volume reads as a strategic organisation of planar and volumetric components that interact without resolving themselves into a single interpretation.

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51 Rowe suggested that the five planes dividing the volume horizontally and the four ones dividing it vertically interact creating a succession in depth as well as an ambiguous figure/ground situation that is analogous to the fluctuating panels of Leger's 'Three faces'. C. Rowe, 'The Mathematics of the Ideal Villa and other Essays', The MIT Press, Cambridge, Massachusetts and London, 1982, p. 161.

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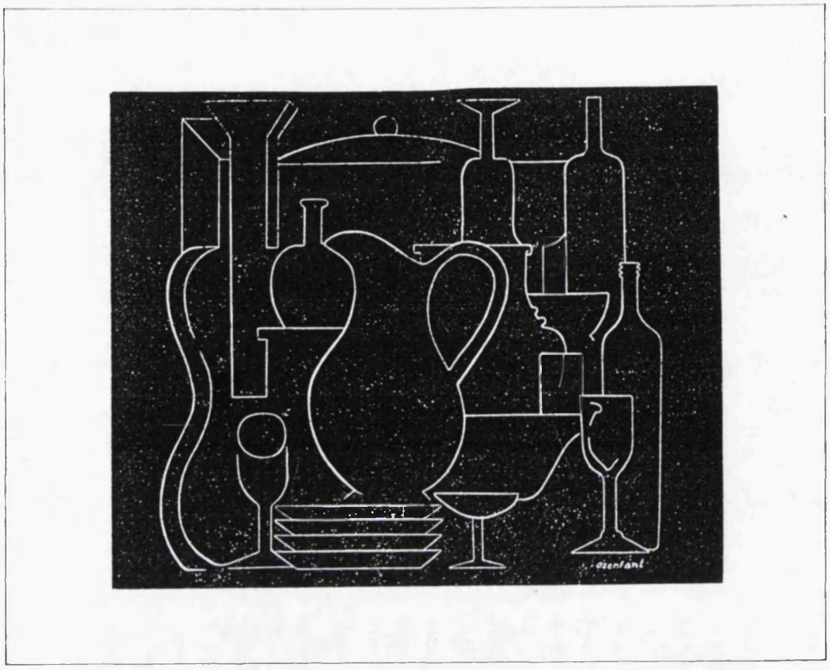


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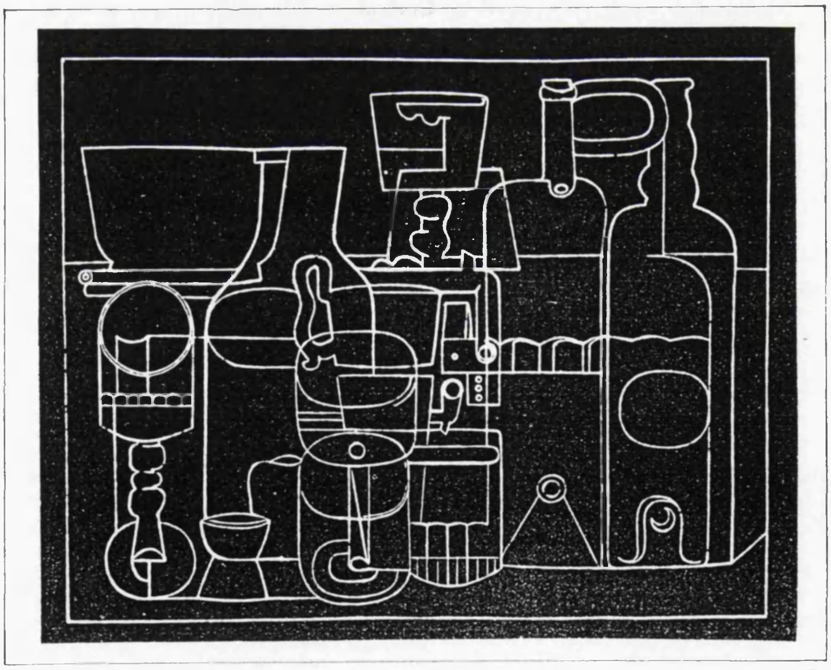

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Besides, the characteristics of Cubism's composition of space, as these are stressed by various authors, seem to be very much the same with the characteristics of Le Corbusier's organisation of plans identified by this analysis. It is beyond the interest of this research to provide an extensive investigation of Cubism. However, some of its fundamental principles are presented here with a view to demonstrate these similarities. These are the following:

- Combination of several points of view of an object within a single image.
- Reduction of the pictorial landscape to its underlying geometry expressed by a network of horizontal and vertical lines and intruding planes. This reduction establishes a shallow space diminishing pictorial depth to the picture plane.
- Dissolution of the figure by the same geometrical grid in a way that it merges with the space of its action, i.e. the picture plane.
- Elimination of sense of volume and mass by an interlacing of overlapping planes.
- Planar ambiguity of these planes creates fluctuating spatial locations in depth.

According to C. Butler these characteristics were intended to demonstrate the contradictions arising when a three dimensional object is represented on a flat surface. As Butler suggests 'the constant arrangement of the pictorial planes in such images attacks the (mimetic) illusion which can allow us to forget that we are looking at an artificial contrivance' [52].

The similarities between Cubism and Le Corbusier, the close relations of the geometric abstraction of Cubism to the diagrammatic nature of the architectural plan as well as Le Corbusier's own preoccupation with Cubism, (illustrations 4.38, 4.39), seem to demand a comparison between his plans and a Cubist painting. However, analysis attempts a comparison of the second floor plan of Villa Stein, (illustration 4.40, p. 304), with Matisses's *La Desserte*, (illustration 4.41, p. 304).

A plan, no matter how it tries to communicate virtual depth and to express the perceptual contradictions inherent in two dimensional representation[53], expresses also a physical reality. Regardless of how it overlays shape upon shape, it satisfies conventions of representation of a three dimensional world.

In this world spaces and their physical boundaries are no longer transparent. Their planar ambiguities are reduced to real less ambiguous situations. If a plan wants to express these situations it has to

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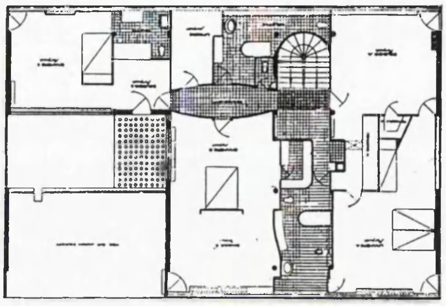
52 C. Butler, 'Early Modernism', Literature, Music and Painting in Europe 1900 - 1916', Clarendon Press, Oxford 1994, p. 67.

53 These contradictions were attributed to the ambiguous figure/ground readings. Illusions and perceptual contradictions are often the preoccupation of most artists like Escher.



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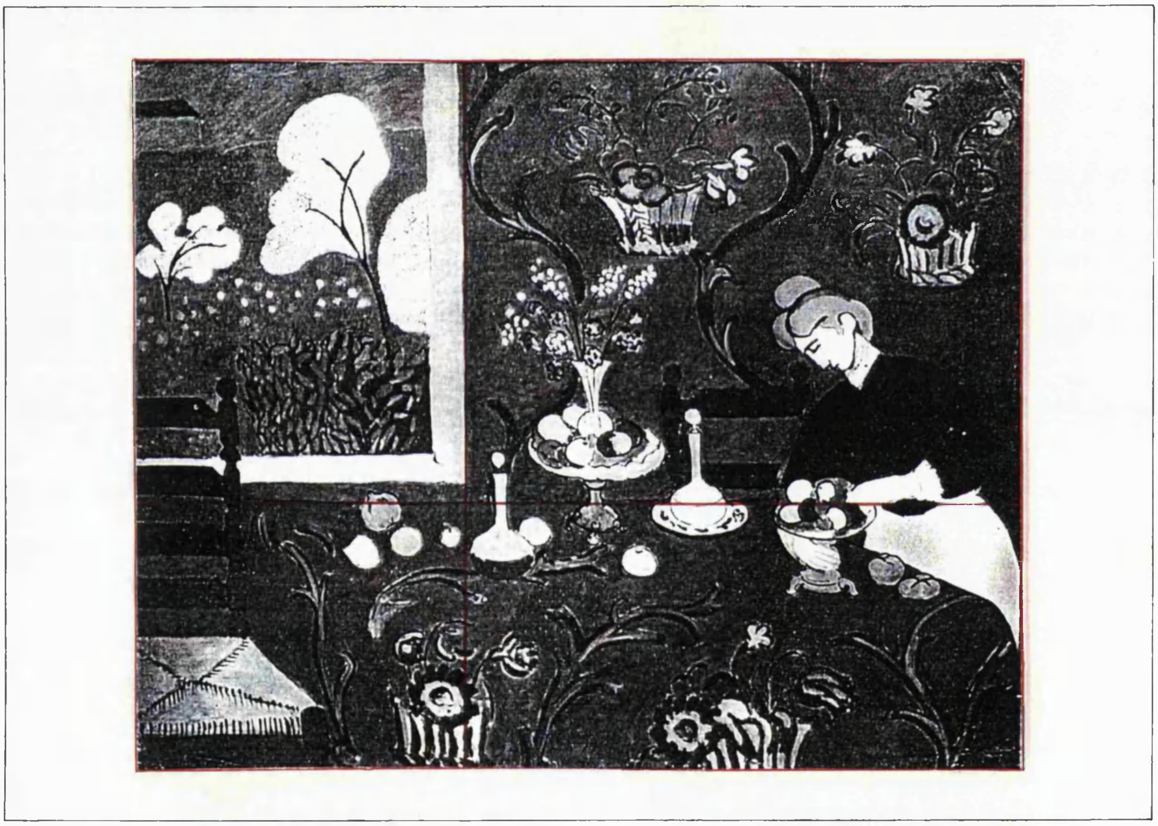

(41)

communicate space with its divisions, its horizontal and vertical connections and its elements of the programme.

A painting like *La Desserte* regardless of its abandonment of the subtleties of pictorial reality with its mass, volume, light and the range of tactile painterly representations is still figurative. In contrast, the diagrammatic nature of Cubist painting breaks down convention reducing figurative and spatial representation. The figurative nature of *La Desserte* does not replace pictorial space with its planar analysis. Like the architectural plan, *La Desserte* satisfies convention providing, thus, a useful ground for comparison.

Both the plan of villa Stein and Matisse's painting are geometrically divided into four rectangles. The proportional relations amongst these rectangles in the painting are close approximations to the ones in the plan. If the horizontal zones of the plan change in a way that the bottom zone takes the place of the top one, then the geometrical grid of the two systems becomes strikingly similar.

The interplay of the wallpaper design and the fabric of the tablecloth with the objects on the table forms the main motif of the painting. This interplay evokes the interplay of the small scale elements, the columns, the sanitary elements, the partitions screening the beds, the WCs, the wardrobes and the dressing rooms, distributed throughout the plan. Finally, the landscape seen through the window seems analogous to the planes of the terraces seen through the void.

Matisse organises pictorial illusion out of four spatial locations. The window forms a distant plane. In front of this plane is the plane of the wall with the wall paper motifs. The objects on the table and the woman figure belong to a third location, while the vertical surface of the table cloth comes forward as the final one.

Le Corbusier organises his plan in a way that four spatial locations can be identified also. The void at the front left corner of the plan is equivalent to the distant landscape plane of the painting. The L shaped interior space is analogous to the surface of the wall and comes second. The plane of the rooms advances a step forward acting like the plane of the objects and the human figure. Finally, the small scale incidents seem analogous to the motifs on the fabric of the tablecloth[54].

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54 The assignment of depth locations to these planes is based on the convention of inside/outside space. This assigns a positive reading to the L shaped interior and brings it the front of the void. They are also based on the convention of the forward advancing of the small elements as mentioned by R. Arnheim. R. Arnheim, 'Art and Visual Perception', A Psychology of the Creative Eye', University of California Press, 1974, p. 228. As mentioned before different locations might be attributed to these elements according to different figure-ground readings. However, the purpose here is not to establish the exact places in depth but to demonstrate the analogy between the organisational principles of the painting's space and those of the plan.

The distribution of the flower motif throughout the picture and the simplified outlines of the trees, the objects on the table and the human figure not just pattern pictorial space in a decorative manner but also flatten this space to the plane of the picture. Thus, the transformation of the painting into an ornament compresses pictorial depth in a manner similar to the compression of depth by Le Corbusier.

- **Architectural representation and the intelligibility of physical space**

Going back to the ways architectural representation expresses physical architectural space it turns out that tripartite composition of Botta in depth establishes figure-ground situations like the one Arnheim reads in Villa Valmarana. On the other hand, the interactive planes of Le Corbusier are dissolved into a disperse interaction with the pictorial rectangle. They seem to declare that if one attempts to apply figure- ground interpretations becomes lost to an endless field of possibilities.

The pictorial surface in Botta composed by a bounded rectangle reads as a *single spatial enclosure*. The void with its apparent oneness stands in front of this enclosure shaping the space around itself. The lines, what has become of the bounded spaces, step also out of this surface creating a contradictory statement of an *interrupted continuity*. This is a sensation of a single unified space, like Bellini's vaulted niche, that flows between the boundaries of the void and the spaces, like the pictorial space contained between the Madonna and the Saints.

The rectangle of Le Corbusier interacting with the spaces and the internal partitions is dissolved and dispersed. It creates no sensation of spatial enclosure. There are cases in which this sensation is possible. These are moments in which individual elements lift themselves from the picture plane to suggest an enclosed space that flows in between their rounded surfaces and the edges of the plane. However, these are dispersed moments and attention is directed back to the gridded pattern of spaces, columns, and surfaces which like the ornamented motifs of Matisse fill this space.

Thus, spatial recession in Botta's plans expresses physical space. *Its tripartite composition allows the viewer to forget that looks at an artificial condition i.e. the condition of flatness.* On the other hand, a simultaneous suggestion and compression of depth in Le Corbusier allows and denies an immediate access to this space. *Le Corbusier showing the viewer the contradictions arising from the representation of space on a plan does not allow him to forget that he encounters not physical space but a flat surface.*

*Thus, Botta seems to make the plan a representation of its spatial structure. Le Corbusier does not allow the plan to express the organisation of space.*

Le Corbusier' s belief of the impossibility of the plan to express the 'true anticipation' of Architecture is, thus, reflected on the ways his plans resist to communicate clearly and simply their physical and spatial organisation. On the other hand, Botta's emphasis on spatial qualities, like the interaction between the building and its landscape, experienced only through walking inside real three dimensional space, is contrasted by a belief that sees the plan capable of expressing three dimensional space.

- **GEOMETRICAL PROPERTIES**

- **Geometrical properties of the shapes**

Analysis suggested that the transformation of the interior in Botta is based mainly on a preservative mode, in which the overall geometrical symmetry on the BF axis directs the organisation of shapes. On the other hand, in Le Corbusier the interior is not characterised by overall symmetry in any stage. There is no local symmetry characterising the distribution of individual components either.

Analysis also showed that apart from the symmetrical organisation asymmetry is incorporated by Botta. This is based on deviations of the small scale components from the overall symmetrical pattern. However, it was suggested that these deviations are balanced by the large scale elements which refer directly to the BF axis.

The approximations and deviations from symmetry create a dynamic type of perception than the one established by an arrangement that is constantly based around a single axis. Subtle deviations of the small scale from the overall pattern attract attention and draw an observer to test these deviations against the obvious symmetries of the large scale.

In Le Corbusier the tension between symmetry and asymmetry stays only at the level of the volumetric articulation. This is because the internal articulation shifts the emphasis from the simultaneous application and denial of symmetry characterising the external organisation to its systematic abandonment.

- **Geometrical properties of the grids**

Botta tends to adopt a preservative mode in which a systematic pattern of occurrence of symmetry/asymmetry transforms the geometrical properties of the interior at stage three to close approximations of the properties of the first stage.

Le Corbusier combines a preservative and an obliterative mode preserving overall symmetry at one stage and denying it at another. Besides, the grid moves from overall symmetry and tripartition to overall asymmetry in the majority of the cases. This way he creates a dissociation between the properties of the last and the properties of the first stage.

- **The relationship between the internal and the external organisation**

The properties of the interior in Botta become close approximations of the properties of the exterior. On the other hand, Le Corbusier does not adopt such a clear approach. The interior in process is allowed to depart away from the overall symmetries of the grids governing the external organisation at one stage, while at the next one is controlled by these symmetries.

Thus, in Botta a single rule organises the houses as wholes. In Le Corbusier an association and dissociation between the organisational principles of the interior and those of the exterior shows that these two systems are treated as a single system as well as two systems that are independent from each other.

Thus, Botta's grids register as simple configurations that are immediately understood. In Le Corbusier the simultaneous acceptance and denial of symmetry creates arrangements that are difficult to understand at a single glance.

Botta also employs asymmetry in the organisation of his grids. However, the preservation of the symmetrical and tripartite organisation of the central geometrical bay running from back to front and of the two bays on its sides throughout the stages allows the overall pattern to prevail. Besides, it homogenises the floor plans at the level of a single house as well as at the level of the whole sample of houses. Thus, the deviations from grid symmetry characterising mainly the small scale articulation read as minor breaks to the overall symmetry. As Gombrich suggests the slight changes to the rhythms of the bays increase the strength of the overall message of symmetry.

In Le Corbusier there is no such consistent pattern occurring throughout the houses. Each grid looks different from the others. Besides, each grid breaks or develops symmetry in a different way from the others. At the first floor of Villa Stein, for example, symmetry takes place at stages two and three. In this case symmetry reads as a property of the small scale articulation rather than as a property of the large scale. Thus, symmetry breaking is captured as a property of the large scale. The lack of a consistent pattern of development of symmetry/asymmetry makes each house a unique case creating difficulties in capturing the organisational logic of these plans.

Besides, analysis showed that in Botta global rules applied from the global to the local scale specify also the positions of the geometrical lines of the interior. Thus, in five out of twelve floors, (5/12), plans at stage three the I/O line index is over 0.70 indicating an increased control of the overall pattern over the local arrangements. In Le Corbusier there is no great degree of coincidence between the geometrical lines of the global and those of the local scale. Nine out of twelve, (9/12), floor plans are described by an index that is below 0.40.

In Botta the systematic tendency to align the physical elements of the interior with those of the exterior creates a simple grid that becomes increasingly defined by physical elements. On the other hand, in Le Corbusier the systematic avoidance of alignment amongst the lines of the interior and those of the exterior creates a grid that lacks physical definition.

Thus, whereas Botta's grid becomes explicitly defined by the figurative elements, Le Corbusier's grid is disguised by the interwoven patterns of the surfaces of these elements. *Thus, Botta offers simultaneous readings of the figurative elements and the grid. Le Corbusier creates independent readings of these systems.*

The integration between shape and grid organisation in Botta attaches linear relations amongst the shapes that transcend their local position on the plan. The viewer is not only informed of relations amongst adjacent shapes but also of relations amongst shapes occupying extreme positions on the plan. Thus, like in an X ray he reads not only the pictorial elements but also a skeleton that holds them together.

In Le Corbusier the linear relations amongst the shapes are rarely read. One sees a patchwork of shapes, or an irregular pattern of fragments of lines into which some of the shapes are analysed. Relations between elements not bound together by proximity fail to register into perception unless a line is extended on the plan.

- **The geometrical organisation and pictorial space**

Examination of the physical properties suggested certain ways in which the physical articulation of the plan expresses spatial depth. In this section analysis examines the role geometry of the plan plays in the expression of pictorial depth as well as in the expression of architectural three dimensional space.

It has been suggested that unlike physical properties which refer to the visible aspects of a shape, geometrical properties refer to those aspects that are not directly visible. It has been also suggested that the systematic gathering of physical elements under a single rule raises a geometrical property to the level of the observable structures. Thus, the systematic gathering of shapes under the co-ordinating role of the BF axis in Botta makes this axis visible. In Le Corbusier, the systematic avoidance of shape symmetry allows the geometrical order to remain invisible.

Further, it has been argued that the gathering of physical elements along a geometrical line provides this line physical definition. Thus, in Botta the gathering of the physical elements of the interior along the geometrical lines of the exterior makes the physical structure a representation of the geometrical structure. In Le Corbusier only fragments of the grid become physically identifiable.

Geometrical properties of a two dimensional nature capture the co-ordination of physical elements on a two dimensional plane. Thus, the more the shape and grid properties become observable the more the two dimensional arrangement of physical elements is highlighted.

Arnheim puts forward a proposition regarding the ways the relative position of shapes and their geometrical relations interact to determine whether a pattern is perceived as two or as three dimensional. He suggests that the pattern in figure a, (illustration 4.34, p. 295), is read as two dimensional because the centres of the circle and the square coincide. In the second and third figure they free themselves from each other because the pattern that tied them together under the co-ordinating force of a single axis ceases to exist. Thus, according to him *the geometrical co-ordination of shapes flattens spatial recession and eliminates the potential of the third co-ordinate to be expressed.*

*In this respect, Botta's co-ordinated shapes and physically defined grids make the visual comprehension of the geometrical configuration possible. Such comprehension attaches planar readings that interact with his tripartite compositions in depth. On the other hand, Le Corbusier's 'buried' grids free pictorial space from the limitations of geometry.*

Thus, it seems that the geometrical analysis of the plans adds a new dimension to the ways the two architects manipulate flatness and depth. Examination of physical properties showed that Botta incorporates only the depth variable whereas Le Corbusier combines both expression and shrinkage of depth. Analysis suggested that Botta does not question the power of the plan to express depth. Le Corbusier points at the contradictions arising on flat representation. Botta through spatial recession expresses architectural space. Le Corbusier through the contradiction between spatial recession and shrinkage of depth expresses the impossibility of the two dimensions to capture the three dimensional complexity of architectural space.

The question that arises then is: *how the geometrical flatness in Botta abides with the expression of depth? Besides, how the hidden grid in Le Corbusier abides with the expression of flatness?*

In Botta the physical elements of the rectangle are symmetrically arranged adding to its recognisability as well as to its distinction from the rest of the components. Therefore, the geometrical co-ordination of the surfaces of the rectangle by the BF axis stabilises the pictorial surface against which the action of the elements happens. Besides, the coverage of the staircase drum and the void by the BF axis establishes the prominent position of these elements on the action plane. Further, the superimposed shapes hold the sides of the composition sending the interest towards the foreground plane occupied by the void.

It seems that it is the clarity of the geometrical relations in Botta that establishes the depth relations. The co-ordination of the elements by the BF axis establishes clear hierarchical relations allowing the elements to occupy clear positions in depth.

In Le Corbusier the absence of overall co-ordination of the physical elements of the rectangle disperses them on the pictorial surface and allows them to step out from this surface. The absence of overall co-ordination of the rest of the components allows them to occupy different positions in depth. In this context, it seems that the absence of a co-ordinating centre in Le Corbusier facilitates the fluctuating depth relations amongst the components.

Going back to the explicit definition of the grid and to its ability to flatten spatial recession, it seems that Botta establishing a clear distinctions of depth can submit his plans to the contradictory statement of shallowness. Le Corbusier's conception of shallowness is different. It is not achieved by the x-ray principle, the ability to see the latticed articulation of lines. It is achieved through the decomposition of elements into a network of intersecting fragments. These fragments result in an awareness of the grid rather than in its actual physical identification. Such identification would act against dispersion undermining the effects of the ambiguity between shallowness and depth.

To summarise, it has been showed that the co-ordination of all levels of properties by a single rule in Botta establishes a simplicity allowing the physical and the geometrical organisation to be immediately understood. This co-ordination communicates a spatial arrangement that is based on a unified interior bounded by the outer boundary and centred around the BF axis.

*It seems that Botta expressing the organisation of space through a simple physical and geometrical structure puts forward a proposition of a spatial experience bound to geometry and to boundary unification.*

On the other hand, in Le Corbusier the principles by which the elements are brought together are complex based on a simultaneous application and negation of rules as well as on a simultaneous overlap and differentiation of various systems of properties. Thus, Le Corbusier establishes a perceptual uncertainty created by the complicated interactions amongst these systems. Perceptual uncertainty of the physical and geometrical organisation of the plan expresses a perceptual uncertainty of the organisation of space. *It seems that Le Corbusier's complex system of decomposed shapes, hidden grids and questioned symmetries suggests that geometry and boundary unification are not the means by which space is experienced both in flat projection and in reality.*

Analysis of the interior space from the point of view of the peripatetic observer at the following chapter is hoped to test these hypotheses.

## SUMMARY AND CONCLUSIONS

It this section the analysis returns to the compositional devices the two architects use. It attempts to explain the design logic of Botta and Le Corbusier in the articulation of the interior as well as to relate this logic to the design logic of the exterior. It also attempts to examine the role this logic plays in the ways the buildings become intelligible.

- **MARIO BOTTA**

Analysis suggested that the transformation of the interior in Botta is characterised by the following principles:

- A consistent development based on a preservative mode that maintains all levels of properties of the first stage.
- A constant association between stages, operations, shapes and permutations.
- A single rule governing the physical and the geometrical properties. This rule determines the positions of the shapes, of their defining lines as well as the distribution of material along their contours.
- A recurrent tripartite arrangement of the plans in depth based on the geometrical and physical oneness of the composition. This arrangement communicates a unified spatial interior organised around the BF axis.

These characteristics were also found to govern the transformation of the volumetric articulation of Botta's houses. The preservation of the properties of the first stage in the transformation of both the internal and the external articulation shows that both the interior and the exterior are governed by the properties of the largest volumetric component. *The physical and geometrical oneness of the volumetric and the internal articulation creates volumes that are representations of the plans. It also creates plans that are representations of the spatial structure.*

The articulation of the volume was also found to comprise a certain course of action, a specific set of transformations and a specific vocabulary of shapes and combinations. *Thus, this design logic characterises the articulation of the house as a whole.* Volumetric Analysis suggested that this logic belongs to an existing world external to the word of possibilities emerging during the design process. *Thus, the articulation of the houses as wholes satisfies pre-existing knowledge of a building form in which each house looks similar to the others.*

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## LE CORBUSIER

The articulation of the interior by Le Corbusier is based on the following principles:

- A development based on both a preservative and obliterative mode. According to these modes the properties of the first stage are alternatively applied and denied. The only exception is the shape organisation which moves away from the local symmetries characterising the first stage.
- A certain association between stages and operations.
- A consistent pattern of association between certain stages, certain shapes and certain combinations. However, there is a general type of shapes used rather than a specific shape. Besides, there is a general way in which these shapes are related to each other rather than a specific way. This allows variation within recurrent application of general patterns.
- Lack of a single rule that organises the physical and the geometrical properties of the interior. There are rules that continue the decomposition of the block into the interior as well as rules that establish its hierarchical distinction[55]. Besides, there are rules that retain the grid symmetry of the first stage and rules that suspend them.
- The complexity of the physical and the geometrical articulation with its decomposed fragments of shapes, its applied and denied symmetries and its interlocking surfaces creates a simultaneous expansion and contraction of depth at the level of pictorial representation. This symbiosis of fragments and shapes, of depth and plane, reduces the possibilities of the plan to communicate the organisation of space.

The same principles were identified as organising the volumetric appearance of Le Corbusier's houses. Thus, both the articulation of the exterior and the interior are characterised by a simultaneous application and denial of the properties of the largest volumetric component.

Besides, both the external and the internal articulation are characterised by a design logic that creates coincidence and differentiation between the higher and the lower levels of abstraction. Further, both articulations employ a large implicit syntax of shapes and combinations that allows the houses to maintain visual variety.

Both architects, thus, develop a consistent logic in the articulation of their houses as wholes. However, analysis shows that Botta's logic directs the design in process to satisfy the limitations of a higher order concept, the concept of the block. On the other hand, Le Corbusier allows the design in process to develop towards internal possibilities emerging through a course of action. Besides, he applies a certain form of control of the higher order concept over these possibilities.

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55 The distinction between thick and thin surfaces expresses a distinction between the outer and the inner surfaces.

Le Corbusier' s known expression 'The plan is the generator' seems to demonstrate this point. Although he implies a three dimensional articulation that exclusively arises from the organisation of the two dimensions, he expresses a belief on the potential of the internal arrangement to influence the overall articulation of the house. Thus, he suggests that in design possibilities emerging at a local level, i.e. at the level of the internal planning, can affect the organisation of the whole.

The design logic of Botta based on a pre-established system of logical relations facilitates an immediate understanding of his buildings. It seems that the constant direction of the design in process to satisfy pre-existing knowledge of a building form makes both the interior and the exterior a representation of the spatial organisation.

In Le Corbusier the complex symbiosis of existing and discovered norms, of decomposition and re-assertion of familiar patterns establishes a perceptual uncertainty. Thus, ambiguous and conflicting readings of both the external and the internal appearance of his buildings seem to deny a clear and straight forward decipherment of their spatial logic.

- **Summary**

To summarise, two different approaches to composition identify the differences between the two architects. Botta adopts a preservative approach directing the plan in process to satisfy the formal principles governing the house as a whole. Le Corbusier follows a preservative and an obliterative approach that abides with the properties of overall organisation while at the same time allowing the local scale and the elements of the interior to depart from the global limitations. Two kinds of understanding are generated that are clearly distinguished from each other. Botta's plans are grasped as simple formal configurations mapping the organisation of the house as a whole. They are also seen as pictorial expressions of a simple spatial organisation and of an architectural experience founded on a lucid geometry. Le Corbusier's plans are understood as complex configurations unable to express an overall arrangement by a single principle. They are also seen as pictorial metaphors of a complex spatial experience requiring multiple view points and dynamic exploration. Analysis of the interior from the point of view of a peripatetic observer in the next chapter will attempt to relate the formal properties of the volume and the plan to the spatial properties observed in real experience.

# Geometrical Walks in Architectural Space -

# The Synchronous Order of Geometry and the Sequential Experience of Space

## Volume two

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# Chapter Five

# SPATIAL ANALYSIS

# • INTRODUCTION

## • How buildings are experienced from the inside?

The analytical search for what connects formal order to spatial experience has been organised such as it branches out in two directions. On the one side, the organisation of elements to geometrical patterns where shapes, lines, axes and symmetries are traced, with or without mental effort, and analytically described. On the other side, the embodiment of lines and shapes into surfaces and spaces that are encountered sequentially in the course of movement. Having explored the first direction, the study moves to the second one. It poses the question: *How the space of visual experience is structured and how it communicates its organisation to the spectator?*

This kind of inquiry will also seek the connections between the two directions asking: *How spatial experience as a set of successive spatial events enables the retrieval of the synchronous organisation of these events into a coherent physical and geometrical whole?*

It has been already suggested that through spatial experience a building communicates two things: one is its social content, i.e. the ways it fulfils social purposes and arranges social relations. The other one is its visual content. How it stages visual fields and directs the spectator through spatial sequences. It is this second level of content this analysis focuses on: *How buildings are visually appreciated as physical systems of a specific appearance irrespectively of their social performance?*

In chapters two and three it was suggested that the question of how an observer grasps the organisation of space based on the visual information he receives locally by moving about *can be based on the spatial, physical and geometrical characteristics that stay invariant in the transformation of this information caused by movement in space*. It was also suggested that *it is through these invariant characteristics that the physical and the geometrical properties of form can be grasped during spatial experience.*

These suggestions were formulated and tested against existing theories and elementary examples of layouts. In this chapter analysis aims not only at answering the questions set above but also at testing these hypotheses against real architectural examples.

## • A hypothesis - a first description of similarities and differences

A first hypothesis regarding the answers to the above questions was formulated at the end of the previous chapter. Looking at the plans of the eight houses as representations of actual space, it was suggested that, in Botta, characteristics like simplicity and regularity in the two dimensional and the three dimensional extension of 'implied' space communicate the spatial structure with easiness. These characteristics, it was also argued, express that formal order is brought directly into level of spatial experience.

In Le Corbusier, it was suggested that the complex formal articulation of the interior cannot contribute to an immediate and straightforward understanding of the spatial system. Besides, the burial of the geometrical grid behind the irregular configuration of the physical structure suggests that formal ordering is not easily deciphered during spatial experience.

An examination of the interiors of the houses carried out in this chapter reconfirms these hypotheses. It argues that in Botta's houses one witnesses a synchronisation of distant and close spaces, a recurrent pattern of interrelationship amongst the global and the local scale components, the outer and the inner surfaces and a geometrical co-ordination of visual information by the back to front axis. In Le Corbusier there is less synchronisation of global and local scale visual information, of outer and inner surfaces, less similar parts in similar relationships and no geometrical co-ordination of visual fields.

Thus, in Botta there are global scale spatial, physical and geometrical characteristics that stay invariant in the transformation of visual information caused by the observer's movement in space. In Le Corbusier there are only local scale characteristics that stay invariant. Analysis argues that these differences are based on the different ways the two architects approach the transformation of spatial articulation. Botta preserves the properties of the first stage. Le Corbusier employs both a preservative and an obliterative mode of transformation. However, he seems to favour the latter over the former.

The identification of these properties lead to a first set of conclusions in relation to the ways intelligibility is structured during spatial experience. Botta's layouts are revealed almost at once and become intelligible to an almost *static observer*. In Le Corbusier experience is *dynamic* and intelligibility relies on movement. Invariant characteristics and repetitive visual patterns in Botta construct a *deterministic experience* subjecting intelligibility to inferential processes. Changing characteristics and lack of repetition in Le Corbusier generate a *probabilistic experience* challenging probable inferences and assumptions. Spatial, physical and geometrical relations in Botta are successively synchronised constructing a *continuous spatial experience*. In Le Corbusier relations are made asynchronous constructing a *discontinuous experience*.

It will be suggested that the two different approaches to transformation not only result in two different kinds of intelligibility but also have different effects in the ways in which the formal properties are retrieved during spatial experience. In Botta the physical and geometrical properties of the spatial structure are subjected to the physical and geometrical properties of the formal structure. In Le Corbusier the two levels of structure develop independently of each other. In the former, space as a sequential medium is subordinated to physical and geometrical regularity making the formal properties directly observable. In the latter, the lack of regularised patterns of visual information delays access to these properties. In Botta spatial procession is formally motivated subordinating spatial narrative to formal pattern. In Le Corbusier this pattern is turned into a backdrop. Spatial progression is the main protagonist and the only medium to its hidden formal coherence.

In this respect, analysis reconfirms the hypothesis put forward by the literature review and by the analytical model formulated in chapter three: invariant spatial, physical and geometrical characteristics observed during the course of movement expose the synchronous plane of formal order to the diachronous plane of space.

The discussion of how the viewing of these buildings is structured extends to the identification of kinds of viewers created by the buildings of these architects. Botta seems to want his viewer to move in a certain way, observe the buildings from few and specific points, and see them only once. Le Corbusier seems to invite the viewer to move in a variety of ways, observe the buildings from many and different points, and see them more than once. Compelling his viewer into a specific route that exposes architectural construction, Botta makes his intellectual mechanisms evident prior to the sequential material of space. Le Corbusier makes this material the primary element while at the same time inviting the viewer to discover the hidden mechanisms of construction.

By offering access to the constructive mechanisms of space and form, Botta turns his viewer to a passive receptor. By withholding knowledge of such mechanisms, Le Corbusier, arouses the viewer's keener interest constantly inviting him to engage and participate into the dissection and reconstruction of space.

It will be concluded that the kinds of spatial experience and the kinds of viewers become mappings of the compositional logic the two architects possess. A deterministic spatial experience in Botta reflects a deterministic compositional approach based on the realisation of a preconceived global order. A probabilistic spatial experience in Le Corbusier reflects a probabilistic design approach. This approach constantly subjects the global order into a set of probable configurations emerging during design.

The architect and the viewer, composition and spatial experience become thus, complementary entities constantly creating and defining each other. In this respect, analysis argues that the road to a description of intelligibility passes through a description of composition.

## DESCRIBING THE METHODOLOGY

- **The structure of the analysis**

Similarly to the study of the volume and the plan this analysis progresses from the global to the local scale articulation and from the abstract state to the specific state using the stages defined by Plan Analysis. However, instead of looking at the interiors as two dimensional representations that are seen at once, it concentrates on how they are experienced as sequences of spaces. More particularly, instead of looking at the ways the layouts are seen simultaneously as interactions of shapes, it looks at how they are seen sequentially when only a part of them is visible in every step.

Following the general hypothesis that spatial patterns interact with formal ones through spatial, physical and geometrical properties that stay invariant in the transformation of visual information analysis examines two levels of structure. One is the spatial structure, while the second one is the physical and geometrical ordering of this structure.

Thus, the examination of each house is divided into three parts:

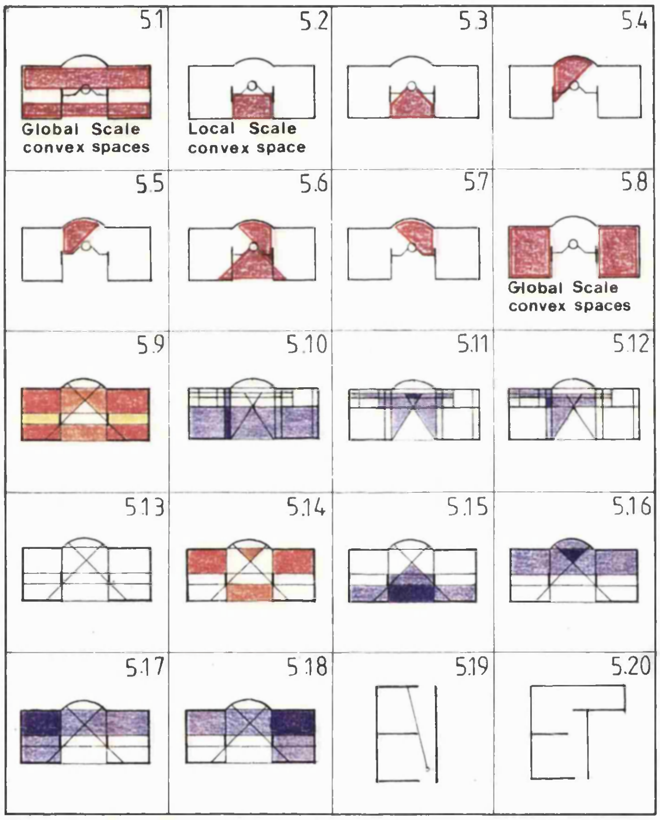
- The first part focuses on spatial properties and on the ways these are revealed to a peripatetic observer. These are described through a number of spatial parameters that are analytically explained in this section.
- The second and third part look at the physical and geometrical characteristics of space. They examine the degree to which physical and geometrical regularity is built into the structure of visual information co-ordinating visual fields and guiding spatial experience.

- **PART ONE - SPATIAL PROPERTIES**

- **A MODEL FOR REPRESENTATION - A PROCEDURE FOR ANALYSIS**

- **Convex and overlap analysis**

In chapter three it was suggested that a study of spatial properties and of the ways they relate to the formal properties has to be based on analytical tools that construct a homology between physical, geometrical and spatial representation. This homology, it was proposed, is possible through the notion of *convexity* and *overlapping convexity*.


5.1
Global Scale convex spaces
5.2
Local Scale convex space
5.3
5.4
5.5
5.6
5.7
5.8
Global Scale convex spaces
5.9
5.10
5.11
5.12
5.13
5.14
5.15
5.16
5.17
5.18
5.19
5.20

**T5.1**

Based on these notions certain analytical concepts are established each of which accounts for a specific spatial property. These are:

- Convex spaces
- Overlap units
- Most connected units
- Visual fields
- Short path units

- **Convex spaces**

The plans are broken down into convex spaces, fig. 5.1-5.8[1]. Analysis uses the definition of convexity as proposed by Hillier and Hanson, i.e. convexity exists 'when straight lines can be drawn from any point in the space to any other point in the space without going outside the boundary of the space itself'[2]. Hillier and Hanson construct a convex break up based on the fewest and fattest convex spaces that cover a layout. Instead of the fewest and fattest convex spaces this analysis uses all possible longest and fattest convex spaces constructed by the extensions of lines defining the physical elements of the houses. These extensions are drawn from the end points of these surfaces and stop when they meet a blocking surface.

Glazed material is considered as both blocking and enabling the extension of a convex space through its mass[3]. This can be explained better by figures 5.4, 5.5, 5.6 and 5.7. The triangular convex spaces at figures 5.4 and 5.6 extend through the glazed surfaces of the void covering both the inside and the outside space. The same surfaces are also considered as interrupting the extension of the oblique lines to define the trapezoidal convex spaces shown in figures 5.5 and 5.7.

Analysis distinguishes between *Global Scale convex spaces* , (fig. 5.1, 5.8), and *Local Scale convex spaces*, (fig. 5.2-5.7). The former extend throughout the plan at length or at width providing global scale visual information. The latter do not reach throughout the plan offering more restricted information.

The Global Scale convex spaces are examined independently of the rest of convex spaces to enable a separate study of the global scale convex structure, (TBH1 5.1, fig. 1, 6, 11). Red and blue colours are

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1 In these figures convex spaces are presented analytically for the ground floor of BH1 at stage one. An analytical representation of convex spaces is also offered for each house in each stage, (see tables in p.p. 353-364, 391-402). In these tables a maximum of six or seven non overlapping convex spaces is drawn each time to avoid confusion emerging from overlap if convex spaces are all drawn on a single plan.

2 B. Hillier, J. Hanson, 'The Social Logic Of Space', Cambridge University Press, 1984, p. 98.

3 Convex spaces are considered as extending through glazed surfaces only when these surfaces stretch from floor to ceiling. In the cases of conventional windows convex spaces do not extend to cover both the interior and the exterior.

used to indicate the distinction between Global Scale convex spaces extending at width, (red), from those extending at length, (blue). Analysis looks at the patterns of the distributions of these spaces on the layouts. The more a layout is covered by Global Scale convex spaces the more it offers global scale information from every single location. On the other hand, the fewer the global scale convex spaces the less visual fields extend throughout an interior.

- **Overlap units**

When all convex spaces are drawn on a plan this is divided into smaller spatial units, (TBH1 5.1, fig. 16, 17, 18, p. 319). Some of these units are produced by the overlap of a number of convex spaces, (***overlap units***). The number of spaces visible from each unit is the *overlap value* of this unit. This is represented using colours that range across the purple hues. Deep hues show a high overlap value, while light hues show a low one. Lack of colour indicates those units from which a single convex space is visible only.

Analysis distinguishes between ***Global Scale overlap units, Global-Local Scale overlap units*** and ***Global-Local Scale units***. Global Scale overlap units belong to two or more Global Scale convex spaces. An example of these units is given in fig. 5.9, (p. 319). These are the units marked by deep orange colour arising through the overlap of the Global Scale convex spaces extending at length, (fig. 5.1, p. 319), with those extending at width, (fig. 5.8, p. 319).

Global-Local scale overlap units belong to one Global Scale convex space and one or more Local Scale convex spaces. These units are indicated by light orange colour in fig 5.9, (p. 319). They are constructed by the overlap of the Global Scale convex spaces seen in fig. 5.1, 5.8, (p. 319), with the Local Scale convex spaces seen in figures 5.2-5.7, (p. 319). Finally, Global-Local Scale units belong to a single Global Scale convex space only. These are shown in yellow colour in fig. 5.9, (p. 319).

The Global Scale overlap units provide visual information about two or more convex spaces that reaches the outer sides of the plan at width or at length or in both directions. The Global-Local scale overlap units and the Global-Local Scale units offer visual information that extends throughout the plan along a single direction. Analysis refers to all these categories using the general term ***Global Scale units***[4].

Another way of looking at the amount and the kind of visual information transmitted inside a layout is to examine the ratio of the Global Scale units to the total number of spatial units, ***(Global Scale-Unit index)***. High values indicate systems with a large number of Global Scale units, while low values indicate systems with a small number of such units. The higher the value of the Global Scale-Unit index the more global scale information is offered. The lower this value the less visual fields reach the outer limits of the plan.

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4 Different terms will be used only in the case a distinction between the three categories of units is needed.

The location and the patterns of distribution of the Global Scale units on the plans are also significant. If these units are close to each other long views reaching the length or the width of the layout or both are constantly retained from one step to the other. If they are distanced from each other these views are not present in every step. The former transmit global scale information in a continuous way, while the latter in a discontinuous one.

- **Most connected units**

The analytical tools mentioned so far account for the degrees and the types of visual information transmitted in a layout as one moves from one convex space to the other or from one spatial unit to the other. They also account for the degree to which visual information *remains constant* from any spatial point belonging to the same spatial component, i.e. a convex space, a global scale unit or an overlap unit. This is because according to the definition of convexity and overlapping convexity proposed in chapter two convex spaces, the spatial units situated on them and the overlap units constructed by the intersections of these spaces offer visual information that remains constant from every spatial point in these elements.

This analysis is also interested in the degree to which visual information remains constant as one moves from one spatial component to the other. Thus, it looks at whether there is constant visual information transmitted from a number of steps passing over different spatial components.

One way of doing this is to look at the number of units from which each unit is visible in each layout. These are the units situated at the same convex spaces with the unit under examination[5]. A value is attributed to each unit based on this number, (***invariance value,*** TBH1 5.1, fig. 19, 20, 21, p. 327).

The ratio of this number to the total number of spatial units in a layout accounts for the extent to which spatial units participate in visual fields, (***Invariance-Value index***). This will give a value between 0 and 1, with low values indicating a unit that is 'seen' only from a small number of units and high values a unit that is 'seen' from a large number of units, (***most connected units***).

The property of a unit to be 'seen' from other units is reversible, i.e. this unit 'sees' also the others. Therefore, the invariance value index accounts also for the number of units each unit 'sees' to the total number of units, i.e. for the degree of visual information revealed from each unit. Thus, low values describe units that reveal small amount of information, whereas high values units revealing almost the layout as a whole. Besides, the more a single unit 'sees' every other unit the more visual information is synchronised and offered from a single location.

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5 According to the definition of convexity every spatial point within a convex space 'sees' every other spatial point of this space and consequently every other spatial unit within this space.

- **Visual fields**

A high Invariance-Value index is not always an indication of how much expansive the visual field is. This is also determined by the size of the units that are connected together. For example visual fields offered from the overlap units at the front part of the second floor at BH1, (fig. 5.10, p. 319), reveal a larger area of the layout than visual fields constructed from the most connected units, (fig 5. 11, 6.12, p. 319). From these units it is a large number of spatial units that are visible rather than a large area of the plan.

Therefore, the analytical tools are combined with visual fields to enable a description of subtler distinctions in terms of the spatial experience created in the layouts. Visual fields are drawn from spatial units with a view to *describe visual information that stays constant from every spatial point situated along the periphery of this unit.* These kinds of visual fields are the intersections of all isovist fields constructed from peripheral points in a unit[6]. Analysis uses the intersections of isovist fields to eliminate the aspect of transformation in visual information transmitted from different points. This is because it concentrates on those parameters that stay invariant as an observer changes his position rather than on a simple representation of visual fields.

- **Short path units**

The maps mentioned so far look at the ways a layout is experienced by an observer that does not take any specific observation route inside a layout. Another way of looking at how a layout can be experienced is to look at how it can be seen in the most economical way. This is possible through a map that consists of the fewest possible spatial units it is necessary to visit, in order to see it as a whole. These are called ***short path units*** constituting the shortest path necessary to construct a complete picture of the layout.

To start drawing the short path units analysis looks at which is the unit/units revealing the largest possible amount of information that is also closest to the point from which a layout is accessible. Then it proceeds to the definition of those units exposing as much information as possible that are accessible from the units defined previously through the minimum number of steps[7]

For example in the layout of BH1 in stage one, fig. 5.13, (p. 319), the short path consists of two units situated on the back to front axis at the front and the back of the plan and two units each of which is situated at the back left or right corner fig. 5.14, (p. 319). Views from the front central unit reveal the front part of the layout and the whole recessed area from which the layout is accessible, fig. 5.15, (p. 319). The visual field from the back central corner exposes the back part of it, fig. 5.16, (p. 319).

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6 For a definition of the isovist field see chapter one, p. 92.

7 Each spatial step is seen as taking place through movement from one spatial unit to the next.

Finally, the units at each of the two corners reveal the left of the right side of the plan, fig. 5.17, 5.18, (p. 319).

Although the back part of the layout can be seen from the trapezoidal units on either side of the axis, the central one exposes it within a single step. In this sense it prevails in the definition of the most economical way of moving in the layout and seeing most of it. Finally, the units at the front left and right corner also reveal the left and right sides of the layout. However, they are more distanced from the central unit at the back than the ones at the back left and right corners.

There can be cases in which there are symmetrical short path units exposing the same area in a layout and having the same relation with the rest of the short path units in terms of steps that connect them, (TBH1 5.1, fig. 9, 14, p. 327). In these cases both units are taken into consideration. Although a single unit is enough analysis considers the element of choice offered to an observer to occupy any of these units to receive the relevant information.

The distribution of short path units is studied to see the scale of movement required to obtain information about the layout as a whole. Short paths consisting of units situated next to each other indicate that a layout becomes knowable through small scale exploration. On the other hand, those consisting of units that are distanced from each other indicate layouts that are revealed through large scale movement.

## • PART TWO - PHYSICAL PROPERTIES OF SPATIAL ARTICULATION

Analysis of the physical properties concentrates on the ways visual fields are constituted by surfaces. More particularly, it focuses on the degree to which the outer surfaces of the block, the surfaces of the voids and the surfaces of the internal volumes become visible during spatial experience.

One way of looking at the ways the external surfaces participate in visual fields is to look at whether Global Scale convex spaces are defined by the outer surfaces of the volume. In this case the outer surfaces are seen as physically continuous elements in their full length. They are also invariant features of every visual field produced from these spaces.

The Global Scale-Unit index enables a further examination of how the outer surfaces participate in visual fields. High values for this index indicate that there is visual access to the outer boundary from many positions. Low values indicate the opposite. Besides, when Global Scale units share their defining sides contact with different sides of the block is constantly retained over a number of spatial steps.

The patterns of distribution of the overlap units offers an account of the degree to which surfaces are synchronised. When overlap units cover the layout as a whole sharing their defining sides surfaces are constantly interrelated. Besides, constant contact with certain surfaces is constantly retained over a number of steps. When overlap units spread at different locations separated by intervening non overlap units simultaneous awareness of surfaces is not constantly provided. Besides, there is no constant contact with surfaces in the transformation of visual information.

To examine the degree to which visual fields synchronise the outer and the inner surfaces analysis looks at the Global Scale convex spaces and the Local Scale convex spaces that overlap. The more these spaces overlap constructing multiple layers of overlap units the more all kinds of surfaces are simultaneously visible in a layout. The less they overlap the less surfaces are synchronised.

For example, in TBH1 5.3, fig. 3, (p. 331), the convex spaces marked in blue colour do not overlap with the Global Scale convex spaces. From these areas only the defining surfaces of a Local Scale convex space are visible. Some of the units belonging to the blue areas are parts of convex spaces that do overlap with Global Scale convex spaces[8].

The configuration of the short path is another parameter determining the ways physical properties interfere in spatial experience. When short path units are situated close to each other the physical system is seen through small scale exploration. When they are separated occupying different locations this system is seen through larger scale movement.

- **PART THREE - GEOMETRICAL PROPERTIES OF SPATIAL ARTICULATION**

Analysis looks at the ways the geometrical properties of spatial articulation interfere in spatial experience and structure the intelligibility of the spatial system. Thus, it examines the geometrical patterns of distribution of the global scale convex spaces, global scale units, overlap units, short path units, the most connected units and the invariance values.

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8 The dual property of units to belong to two different kinds of spaces, i.e. those that overlap and those that do not overlap with Global Scale convex spaces is explained by looking at the figure mentioned above. In this figure the two curvilinear units situated at the back of the layout belong to the convex spaces defined by enclosing boundaries which do not overlap with any of the Global Scale convex spaces presented in fig. 1, in TBH1 5.3, (p. 332). The rectangular units situated in front of the curvilinear units also belong to the enclosed convex spaces. However, they also belong to the Local Scale convex spaces which extending from the left and the right side of the layout overlap with the Global Scale convex spaces extending at width, (marked in deep red in TBH1 5.3, fig. 1, p. 332). The distinction between the two kinds of units is indicated by deep and light blue colour.

To examine this distribution analysis uses the following measures:

- *Symmetry Global Scale convex space index*: This is the ratio of the Global Scale convex spaces that are symmetrical on the back to front axis, (BF axis), in terms of shape, size and position to the total number of Global Scale convex spaces extending at width of the layout.
- *Symmetry Global Scale-Unit index*: This is a ratio measuring the number of Global Scale units that are symmetrical on the BF axis to the total number of spatial units.
- *Symmetry Spatial-Unit index*: This measures the spatial units that are symmetrical on the same axis in terms of shape, size, position and overlap value to the total number of spatial units.
- *Symmetry Invariance-Value index*: This is the ratio of the invariance values that are symmetrically distributed on the BF axis to the total number of spatial units.

The higher the values of these measurements the more Global Scale convex spaces, Global Scale units, overlap units, short path units and invariance values are symmetrically distributed. Symmetrical co-ordination of these elements results in visual information that is geometrically co-ordinated. In this case geometrical properties interfere and structure spatial experience. When there is no geometrical co-ordination amongst these elements geometrical relations are not added to visual fields.

Geometrical co-ordination of visual fields results in repetitive visual patterns. Similar elements will tend to enter in similar relationships. A repetitive structure of information introduces invariant characteristics in spatial experience in the sense that visibility patterns remain the same from a number of different locations. A non repetitive structure of information does not accommodate invariance in spatial experience as visibility relations will look different from each location.

- **RELATIONSHIP BETWEEN FORMAL AND SPATIAL STRUCTURE**

The analytic concepts and measurements presented so far enable a discussion of spatial properties and of the ways they become intelligible in spatial experience. This discussion extends to an examination of how the spatial structure with its physical and geometrical ordering releases access to the formal structure is attempted. This inquiry takes place at the end of this chapter when the analytical results are summarised and compared to those of the previous analyses.

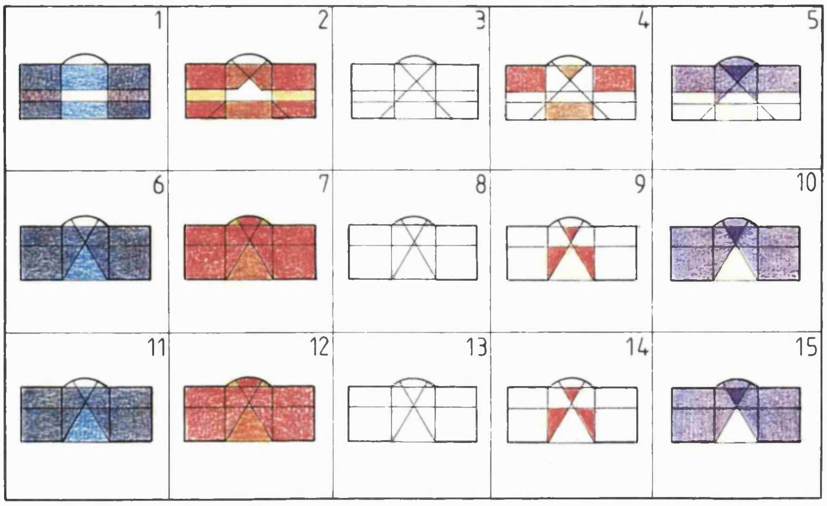
To examine the relationship between the two levels of structure the invariant characteristics described in this analysis are seen in relation to the formal properties. More particularly, it looks at how the invariant physical properties the observer picks up during his movement in space relate to the invariant physical characteristics of the formal structure of the volume and the plan, i.e. to the hierarchical or non-hierarchical categorisation of shapes according to different degrees of recognisability and global significance. For example, the more the outer surfaces feature as constant elements in the visual information transmitted inside a layout, the more they tend to offer access to a formal principle that establishes the priority of this shape over the rest of the components.

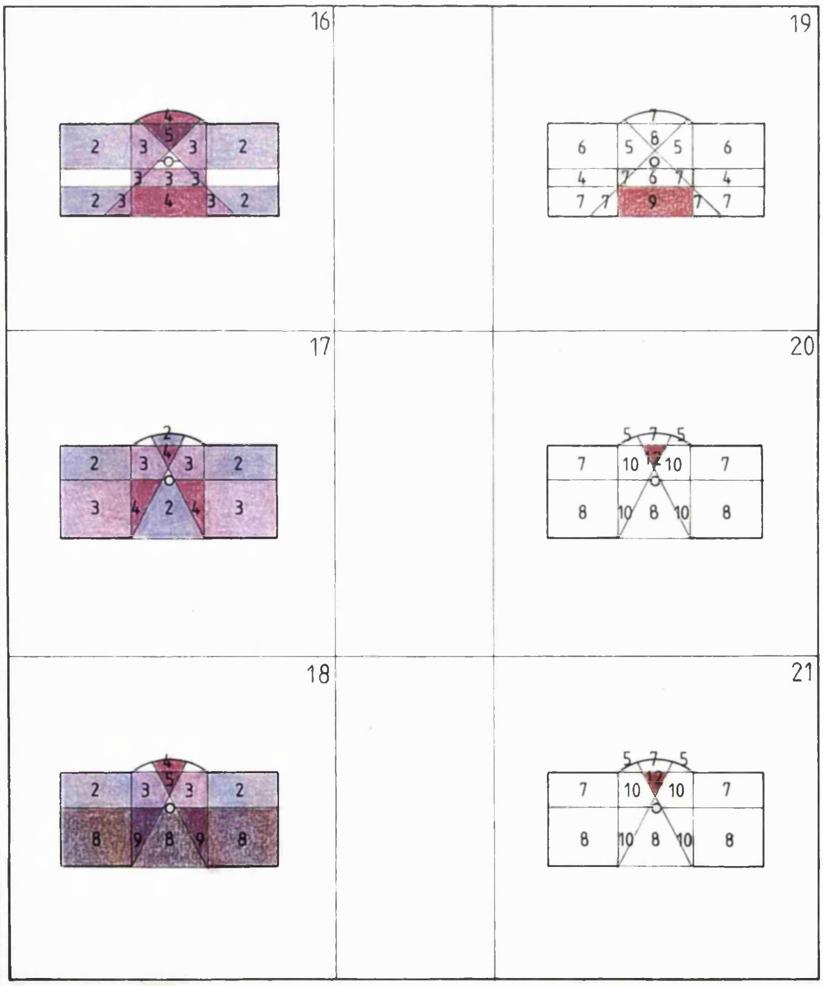
Analysis also focuses on the ways the geometrical invariants picked up during spatial experience relate to the geometrical invariants characterising the organisation of formal order. Thus, if visual fields are symmetrical on the back to front axis, they exhibit invariance in the form of repetitive information. This invariance can reveal the invariant role of the axis in the organisation of formal properties.

- **The structure of this chapter**

Before proceeding to the analysis a clarification of the ways the analytic material is assembled and presented is needed. Similalry to the previous chapters profound similarities amongst the four houses by each architect lead to the selection of one house the detailed description of which is provided in this chapter. For a detailed analysis of the remaining six houses the reader can see the appendix. The account of each house will be followed by a comparative examination of all four houses. Finally, comparison of all eight houses is attempted.

Within this framework of analytical tools and analytic procedures the analysis proceeds next to an examination of Botta's house 1.




## COLOURS

- Global Scale Convex Spaces at length
- Global Scale Convex Spaces at width
- Global Scale Overlap Units
- Global - Local Scale Overlap Units
- Global - Local Scale Units
- Visible area from periphery of central unit
- Unit from which visual field is drawn
- Most connected Units

Table **BH1 5.1**

# ANALYSIS

## MARIO BOTTA - HOUSE AT VIGANELLO - (BH1)

- **DESCRIPTION OF STAGES**

- **STAGE ONE, (TBH1 5.1)**

At stage one the whole area of the plans is covered by Global Scale convex spaces extending at width and at length of the composition[9], (TBH1 5.1 fig. 1, 6, 11)[10]. Those extending at width are symmetrical on the back to front axis, (BF axis), in all floors. Thus, at this stage the ratio of the global scale-convex spaces that are symmetrical on this axis to the total number of these spaces is 1, (Symmetry Global Scale-convex space index: 1, TBH1 5. 6, p. 335).

The overlap units are distributed throughout the layouts sharing one or more defining lines, (TBH1 5.1, fig. 16, 17, 18). Considering the arrangement of all spatial units, i.e. the overlap units and the non overlap units, it turns out that symmetrical spatial units in terms of shape, size position and overlap value are arranged on either side of the BF axis. The symmetrical distribution of the overlap values is visually expressed by the symmetrical distribution of colour used to indicate this value for each spatial unit[11]. It is also numerically expressed through the ratio of the spatial units that are symmetrical on the BF axis to the total number of spatial units, (Symmetry Spatial-Unit index: 1 TBH1 5.9, p. 336).

Figures 2, 7, 12, in TBH1 5.1 present overlap units according to the type of convex spaces they belong to. These figures show that the majority of these units are situated on a Global Scale convex space, (Global Scale units). A large number of these units are constructed by the intersection of one or more Global Scale convex spaces, (Global Scale overlap units, marked in deep orange colour). There are also units constructed by the intersection of one or more Global Scale convex spaces with Local Scale convex

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9 For an analytic representation of convex spaces see tables TBH1 5.13, (p. 353), TBH1 5.14, (p. 354), TBH1 5.15, (p. 355). Each figure in these tables presents a maximum number of six or seven non overlapping convex spaces to avoid confusion emerging from overlap when convex spaces are all drawn on a single plan.

10 The circular column at the centre of the plan is considered as not disturbing the extension of certain Global Scale convex spaces while disturbing the extension of others. The former are the ones in which the column occupies a peripheral position. The latter are those in which the column is inside their area.

11 As it was mentioned in the methodology section the units lacking colour are non overlap units. These are also symmetrically arranged with respect to the BF axis.

spaces[12], (Global-Local scale overlap units, marked in light orange colour). Finally, there are non overlap units which are also situated on a Global Scale convex space[13], (Global-Local Scale units, marked in yellow colour).

The numerical expression of the coverage of the plans by Global Scale units is given by the ratio of the number of these units to the total number of spatial units in the layout[14], (Global Scale-Unit index). At the ground floor this ratio is 0.70, (TBH1 5.7, p. 335). At the first and the second floor it is 1. Therefore, at this stage the majority of visual fields extend throughout the plan either at length or at width, or at both directions.

Besides, these units are symmetrically distributed on the BF axis. This can be seen by looking at fig. 2, 7, 12 in TBH1 5.1, (p. 327). It can be also seen by looking at the ratio of the symmetrical Global Scale units to the total number of spatial units, (Symmetry Global Scale-Unit index: 1, TBH1 5.8, p. 335).

The units constituting the most economical path providing a complete picture of the layout, (short path units) at the ground floor are situated at the back corners and the centre of the plan[15], (TBH1 5.1, fig. 4, p. 327). At the first and second floor this path consists of a triangular overlap-unit on the BF axis and two triangular overlap units located on either side of the terrace, (TBH1 5.1, fig. 9, 14, p. 327). As these figures show the arrangement of the short path units is also symmetrical on the BF axis in all floors. This is also captured by the Symmetry Short Path-Unit index accounting for the number of short path units that are symmetrical on the BF axis to the total number of short path units, (Symmetry Short Path-Unit index: 1, TBH1 5.10, p. 336).

Figures 5, 10, and 15, (p. 327), present the visual fields drawn from the trapezoidal unit on the BF axis. These fields are constructed such as to show what is constantly visible from every spatial point situated along their periphery [16]. The views obtained from the central overlap-unit in these floors cover a large

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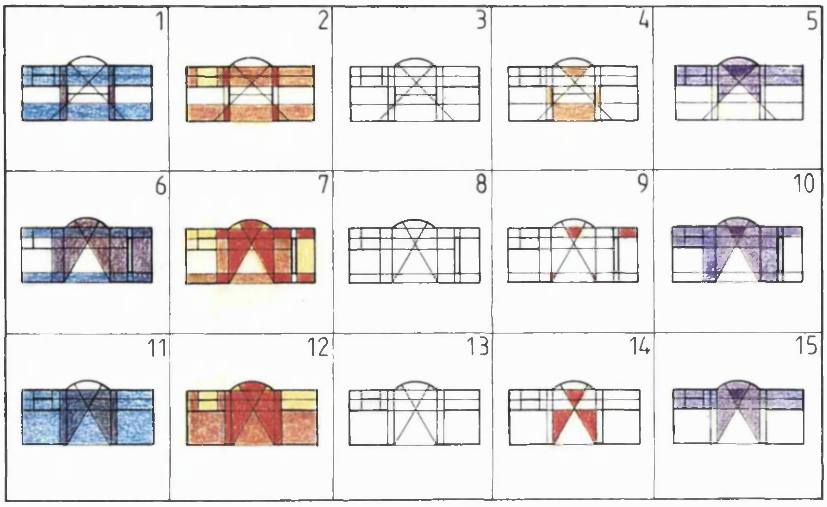
12 As it was mentioned at the methodology section these are convex spaces that do not extend throughout the width or the length of the plan.

13 In the identification and representation of overlap units and Global Scale units the units situated inside the voids are not taken into consideration. This is because these analytical concepts account for the degree of visual information released from a spatial unit that is permeable.

14 Similarly to the identification of overlap units and Global Scale units in the calculations of the Symmetry Spatial-Unit index and the Global Scale-Unit index the spatial units situated inside the voids are not considered.

15 The colours used in these figures indicate the type of convex spaces the short path-units are situated on. Thus, similarly to figures 2, 7, 12 deep orange indicates a Global Scale overlap-unit while light orange indicates a Global-Local Scale overlap-unit.

16 As it was explained in the methodology section visual fields drawn by this analysis do not take into consideration the changes observed as one moves along their periphery. Unlike isovists fields as drawn by



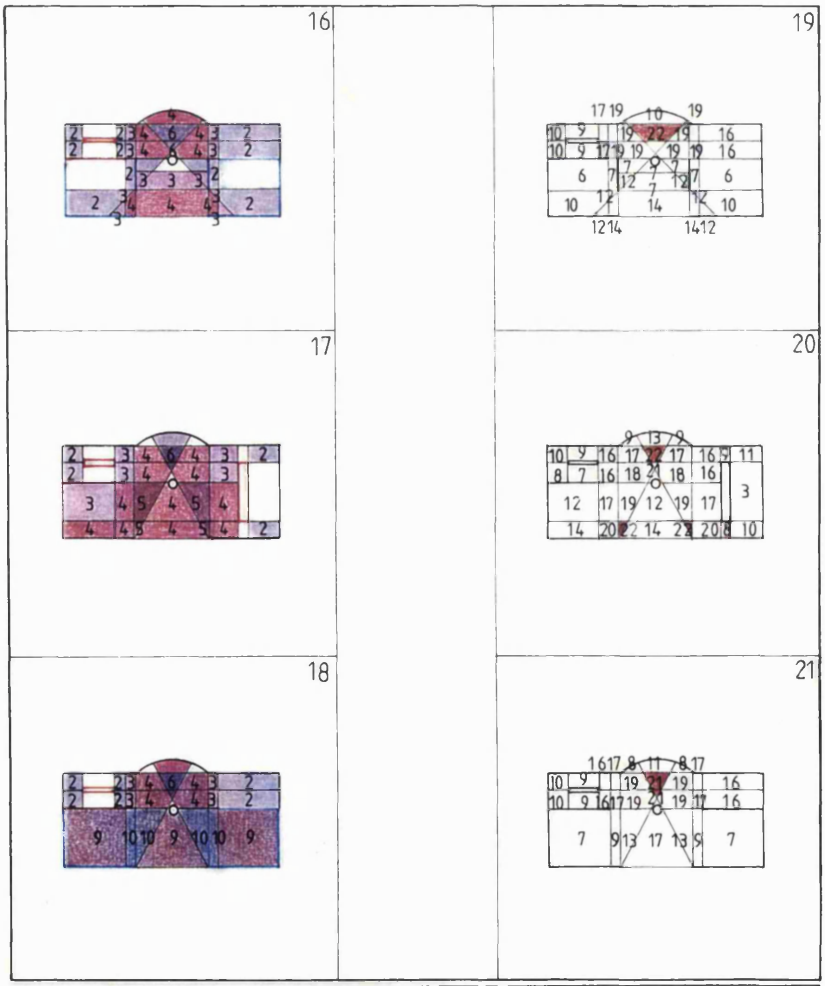




Table **BH1 5.2**

portion of the layout apart from the outside space[17], (TBH1 5.1 fig. 10, 15, p. 327). Thus, unlike the ground floor that is seen from the centre and the corners, these layouts are visible almost from a single location.

The most connected unit, i.e. the unit that 'sees' the largest number of spatial units and is 'seen' by the largest number of spatial units. at the ground floor is the rectangular unit situated at the outside space, (TBH1 5.1 fig. 19, p. 327). The ratio of the number of units connected to this unit to the total number of spatial units in the layout is 0.52, (Invariance Value index, TBH1 5. 11, p. 336). At the first and second floor the most connected unit is the triangular unit situated on the BF axis at the back of the layouts, (TBH1 5.1 fig. 20, 21). The Invariance Value index in both floors is: 0.92, (TBH1 5.11, p. 336).

Looking at fig. 19, 20, 21 in TBH1 5.1, (p. 329) it turns out there is a symmetrical distribution of invariance values with respect to the BF axis. This is also expressed by the Symmetry Invariance Value index measuring the number of units that are symmetrical in terms of invariance values to the total number of the spatial units in the plan. This is 1 in all floors, (TBH1 5.12, p. 337).

- **STAGE TWO, (TBH1 5.2)**

A reminder of the ways these plans are transformed from stage one to stage two is offered here with a view to connect with the previous chapter and present the differences between the two stages. In Plan Analysis the ground and second floor at stage two were defined as resulting from stage one through a superimposition of two rectangles on either side of the void, (TBH1 4.1, fig. 2, 8, see figures of Plan Analysis, p. 254). The first floor was described as being about the addition of a free standing partition at the right side of the plan, (TBH1 4.1, fig. 5, p. 254). Finally, all floors change through the introduction of the staircase at the back left corner of the plan.

Returning to the spatial analysis at stage two, description starts by looking at how the changes introduced at this stage alter the spatial configuration of the layouts. Thus, two narrow Global Scale convex shapes extending at width are defined on either side of the outside space at the ground and second floor, (TBH1 5.2 fig. 1, 11). Further, two triangular Global Scale convex spaces reaching the curvilinear surface at the back are defined on either side of the terrace at the first and second floor, (TBH1 5.2, fig. 6, 11). Finally,

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Hillier et all in which radials connect the corners of the convex space the isovist is drawn from with the edges of physical elements, these fields eliminate radials looking at what stays constant in all fields of vision. In other words, they show the convex spaces a unit belongs to as well as the convex spaces with which this unit shares a defining line.

17 As it was explained before the outside space is not visible from this location because of the circular column situated in the middle of the plan. This column disturbs the extension of a central convex space at width.

two trapezoidal Global Scale convex spaces are situated on either side of this space at the first floor, (TBH1 5.2, fig. 6, p. 290).

The Symmetry Global Scale convex space index at the ground and second floor is 1, (TBH1 5.6, p. 335). At the first floor this index is 0.80[18]. In the previous chapter certain assumptions for the categorisation of degrees of symmetry, i.e. overall symmetry and 'just about' symmetry were established. These are as following: Overall symmetry characterises a distribution of elements when 100 percent of them are symmetrical on an axis. 'Just about' symmetry characterises the distribution of elements when over 70 percent of them are symmetrical on the BF axis. This analysis also takes into consideration the cases in which the percentage of symmetrical elements falls under 70 percent suggesting that these cases are governed by local symmetry[19].

According to these assumptions the organisation of the Global Scale convex spaces at the ground and second floor is characterised by overall symmetry on the BF axis. At the first floor there is 'just about' symmetry governing their distribution.

At length there are two Global Scale convex spaces located at the back and one at the front of the ground and second floor. At the first floor there are two narrow Global Scale convex spaces each of which is situated along one long side of the plan. The disposition of these spaces is not governed by symmetry.

The overlap units cover almost the entire area of the plans, (TBH1 5.2, fig. 16, 17, 18, p. 329). They are located next to each other sharing one or more defining lines. A large number of spatial units are symmetrical on the BF axis in terms of shape, size, position and overlap value. This can be also expressed numerically by the Symmetry Spatial-Unit index. This index at the ground floor is 0.78, (TBH1 5.9, p. 336). At the first and second floor it is 0.67 and 0.70 respectively. Therefore, there is 'just about' symmetry, (ground floor), and local symmetry, (first, second floor), characterising the distribution of the spatial units.

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18 The trapezoidal Global Scale convex-spaces on either side of the BF axis at this floor are symmetrical in terms of position, and asymmetrical in terms of size. However, analysis ignores the size parameter considering these spaces as symmetrical. This is to avoid an extended description that would have to accommodate both the asymmetries in terms of size and the symmetries in terms of the other parameters. Therefore, all calculations of the various ratios ignore the size parameter considering units that are equivalent in terms of shape and occupy symmetrical positions on the plan as symmetrical. It is assumed that although the eyes of an observer in space can capture the differences in size amongst elements, the retention of symmetries in terms of the other aspects contributes to a grasping of these elements as being symmetrical.

19 The reason for doing so is to enable the full range of deviation form symmetry to be examined.

The majority of these units are Global Scale units situated on one or more global Scale convex spaces. This is shown in figures 2, 7, 12 in TBH1 5.2, p. 329. The ratio of these units to the total number of spatial units is captured by the Global Scale Unit index which at the ground floor is 0.80, (TBH1 6.7, p. 335). At the first and second floor this index is 0.85 and 1 respectively.

These units seem to be symmetrically distributed with respect to the BF axis. The degree of symmetry is expressed by the Symmetry Global Scale-Unit index. This index at the ground floor is 0.79. At the first and second floor it is 0.75 and 0.70 respectively, (TBH1 5.8, p. 335). Thus, the organisation of Global Scale units is characterised by 'just about' symmetry in all floors.

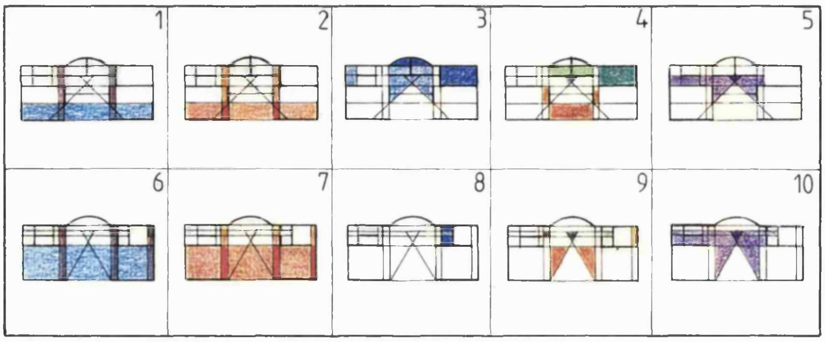
The short path consists of units situated on the BF axis and units on either side of this axis in all floors, (TBH1 5.2, fig. 4, 9, 14, p. 329). The arrangement of these units is symmetrical on this axis with the only exception the unit located at the back right corner of the first floor. The Symmetry Short Path-Unit index capturing the number of symmetrical short path units to the total number of short path units in this floor is 0.75, TBH1 5.10, p. 336).

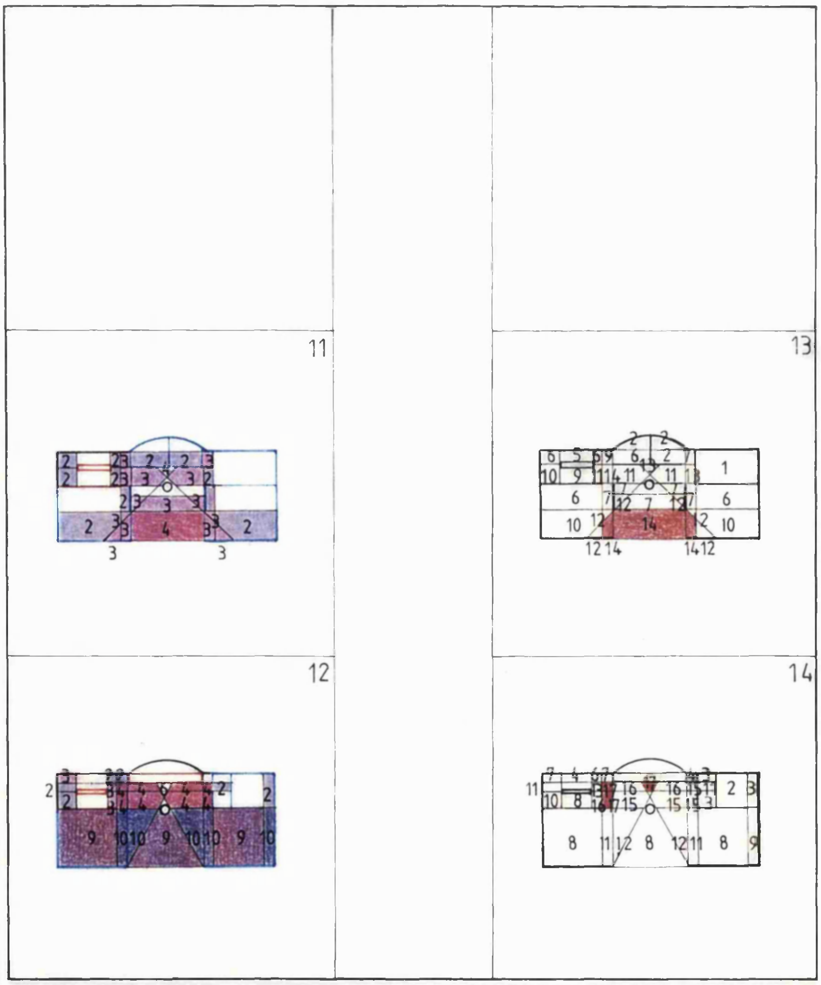
The most connected unit at the ground floor is the trapezoidal unit on the BF axis at the back of the layout, (TBH1 5.2, fig. 19, p. 329). At the first floor the most connected units are the trapezoidal unit on the BF axis and the two triangular units on either side of this axis, (TBH1 5.2, fig. 20, p. 329). Finally, the most connected units at the second floor are the trapezoidal and triangular unit situated on the BF axis at the back of the plan, (TBH1 5.2, fig. 21, p. 329). The invariance value of the most connected units at the ground floor is 0.57, (TBH1 5.11, p. 336). At the first and second floor this value is 0.64 and 0.75 respectively.

Looking at TBH1 5.2, fig. 19, 20, 21, (p. 329) it turns out that a large number of spatial units are symmetrically distributed on the BF axis in terms of invariance value. This is also evident by looking at the Symmetry Invariance Value index. At the ground floor this index is 0.76, (TBH1 5.12, p. 336). At the first and the second floor this index is 0.67 and 0.71 respectively. Thus, 'just about' symmetry, (ground, second floor) and local symmetry, (first floor), characterise the distribution of the invariance values also.

- **STAGE THREE, (TBH1 5.3)**

From stage two to stage three the ground floor is transformed by the superimposition of three elements at the back and the back right corner of the plan, (TBH1 4.1, fig. 3, see figures of Plan Analysis, p. 254). The second floor changes by the superimposition of two rectangles at the back right corner of the layout, (TBH1 4.1, fig. 9, p. 254). There are no changes occurring at the first floor plan.




- Global Scale Convex Spaces at length
- Global Scale Convex Spaces at width
- Global Scale Overlap Units
- Global - Local Scale Overlap Units
- Global - Local Scale Units
- Bounded Convex Space
- Overlap Unit in Bounded Convex Space
- Convex Space not overlapping with Global Scale Convex Space
- Visible area from periphery of central unit
- Unit from which visual field is drawn
- Most connected Units

Table **BH1 5.3**

The Global Scale convex spaces extending at width on either side of the terrace at the ground and second floor are preserved, (TBH1 5.3 fig. 1, 6). Besides, the Global Scale convex spaces extending at length at the front side of both plans are also retained. The Symmetry Global Scale convex space index is 1 and 0.66 respectively, (TBH1 5.6, p. 335). Therefore, the organisation of the Global Scale convex spaces is characterised by overall symmetry, (ground floor) and local symmetry, (second floor).

The overlap units cover mainly the central area and the front corners of the ground floor, (TBH1 5.3, fig. 11). At the second floor they occupy the entire area of the plan apart from certain areas at the back left and right corners, (TBH1 5.3, fig. 12). In both plans these units are arranged next to each other sharing one or more neighbouring sides.

These figures show that a large number of spatial units are symmetrical in terms of shape, size, position and overlap value with respect to the BF axis. This is also expressed by the Symmetry Spatial-Unit index. This index at the ground floor is 0.81, (TBH1 5.9, p. 336). At the second floor it is 0.48. Thus, 'just about' symmetry, (ground floor) and local symmetry, (second floor), characterise the distribution of the spatial units.

A certain number of overlap units are Global Scale units, (TBH1 5.3, fig. 2, 7). The ratio of these units to the total number of spatial units at the ground floor is 0.40, (Global Scale-Unit index, TBH1 5.7, p. 335). At the second floor this index is 0.37. Thus, there is a relatively large number of units offering large scale information about these layouts. This information is mainly offered from the front of the layouts through the glazed surfaces of the outside space.

At the ground floor there is overall symmetry characterising the distribution of the Global Scale units with respect to the BF axis. This is expressed by the Symmetry Global Scale-Unit index which is 1. At the second floor this index is 0.73, (TBH1 5.3, fig. 2, 7). Therefore, there is 'just about' symmetry characterising the distribution of the Global Scale units in this plan.

The short path units are mainly situated on the BF axis, and on either side of this axis[20], (TBH1 5.3, fig. 4, 9). The majority of these units are symmetrical on this axis in both floors[21]. This can be also observed by looking at the Symmetry Short Path-Unit index. At the ground floor this index is 0.85,

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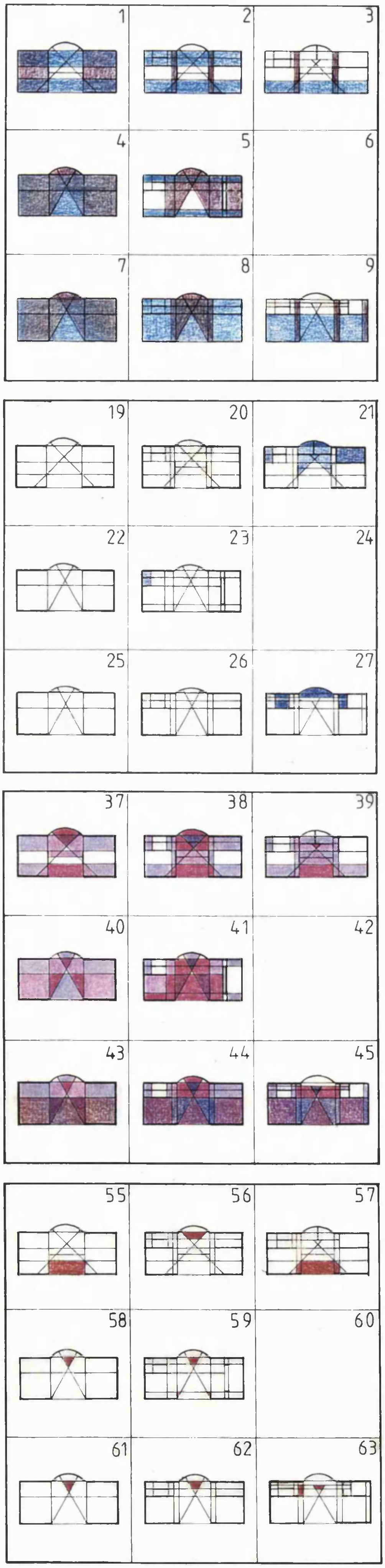
20 As it was explained in the previous stage the deep and light orange colours represent the Global Scale overlap units and the Global-Local Scale overlap units. The colours used to indicate the rest of the units are grey, deep and light green. Grey represents the overlap units arising from the overlap amongst two or more Local Scale convex spaces. Deep green stands for an enclosed single convex space. Finally, light green indicates an overlap unit situated inside an enclosed space.

21 The only exceptions are the short path units situated inside the enclosed spaces at the back right corner of both layouts. These units are situated away from the BF axis having no equivalent units at the other side of this axis.



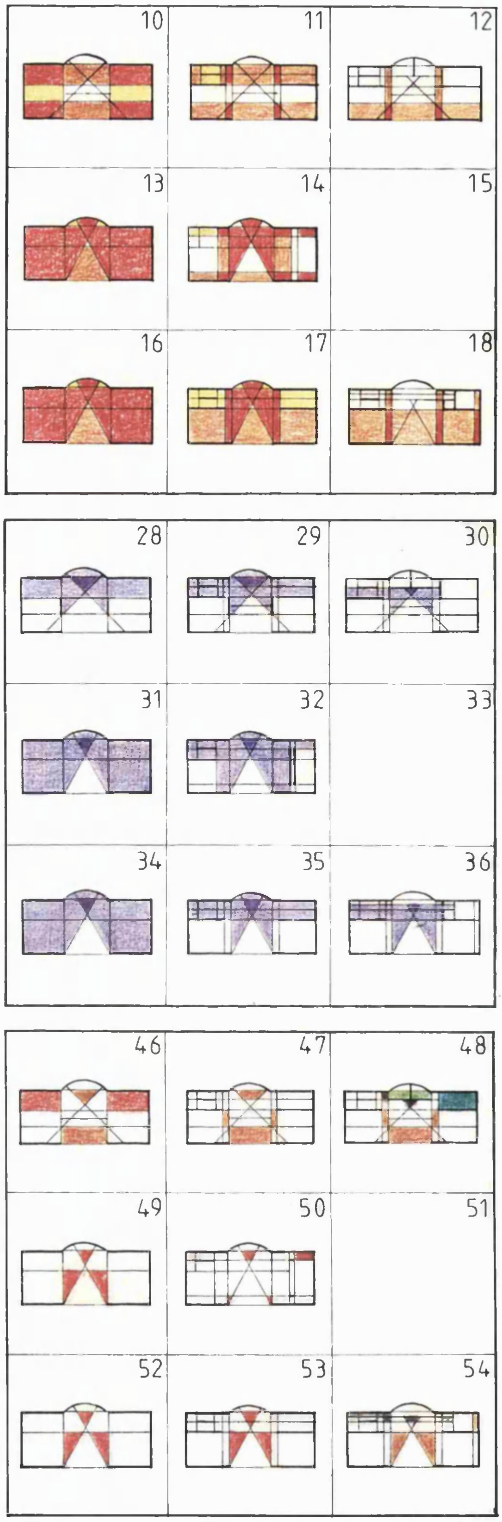




**Table BH1 5.4**
Comparative examination of stages

(TBH1 5.10, p. 336). At the second floor it is 0.50. Therefore, 'just about' symmetry, (ground floor), and local symmetry, (second floor), organise the distribution of the short path units at this stage.

The most connected units at the ground floor are the rectangular unit located on the BF axis and the two trapezoidal units on either side of this axis, (TBH1 5.3, fig. 13, p. 332). At the second floor these units are the trapezoidal unit on the BF axis and the two rectangular units on the left side of this axis, (TBH1 5.3, fig. 14, p. 332). The Invariance-Value index of these units is 0.37 at the ground floor and 0.50 at the second floor, (TBH1 5.11, p. 336). The Symmetry Invariance-Value index is 0.59 and 0.41 respectively, (TBH1 5.12, p. 336). Therefore, local patterns of symmetry govern the distribution of the invariance values of the rest of the spatial units.

- **COMPARISON ACROSS STAGES, (TBH1 5.4)**

- **Spatial properties**

At stage one the entire area of all plans is covered by Global Scale convex spaces and Global Scale units, (TBH1 5.4, fig. 1, 4, 7). Thus, there is visual information that extends throughout the plan either in one or in two or in both directions from every single location.

Besides, at the first and the second floor the entire area of the plan apart from the outside space is revealed from the triangular units located on the BF axis, (TBH1 5.4, fig. 31, 34). This can be also demonstrated by the fact that these units are the most connected units having an Invariance-Value index 0.92 (TBH1 5.4, fig. 58, 61, TBH1, 5.11).

From stage one to stage three the Global Scale convex spaces extending at length at the front of the plan is retained in all floors, (TBH1 5.4, fig. 1-9). From stage two to stage three those extending at width on either side of the outside space are also preserved, (TBH1 5.4 fig. 2, 3, 5, 8, 9). The Global Scale overlap units constructed by the intersections amongst these spaces remain consequently the same, (TBH1 5.4, fig. 10-18). Thus, certain patterns of global scale information and certain positions from which this is offered are preserved.

The Global Scale-Unit index moves from 1 to 0.85 at the first floor, from 0.70 to 0.40 at the ground floor and from 1 to 0.37 at the second floor, (TBH1 5.7, p. 335). Although at stage three this index is reduced, the ratio of the units offering information that extends throughout the layout in one or in two directions to the total number of spatial units is still high. Therefore, there is a tendency to maintain a large number of visual fields synchronising global scale relations from distance.

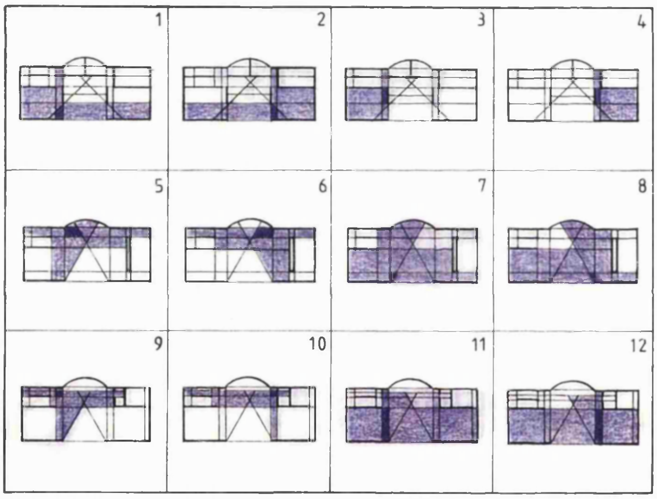



Table **BH1 5.5**

From stage two to stage three the majority of the overlap units at the front of the ground and the second floor are retained in terms of size, shape, position and overlap value[22], (TBH1 5.4, fig. 38, 39, 44, 45, p. 333). The arrangement of these units side by side and their distribution throughout the layouts remain also the same. Therefore, there is a tendency to preserve a constant and successive synchronisation of convex spaces.

A large number of overlap units are Global Scale overlap units, Global-Local Scale overlap units, i.e. they belong to one or more Global Scale convex spaces, or to one Global Scale convex spaces and one or more Local Scale convex spaces, (TBH1 5.4, fig. 10-12, p. 333). This shows that, the synchronisation of convex spaces is about a synchronisation of global and local scale relations.

This can be demonstrated by TBH1 5.4, fig. 19-27, (p. 333), presenting the convex spaces that do not overlap with a Global Scale convex space, (marked in blue colour). As these figures show there are very few units of this kind. In other words, in these layouts there is constantly simultaneous information about the global and the local scale.

The short path maps show that each stage retains the shape, size and position of particular short path units defined at the previous stage, (TBH1 5.4, fig. 46-54, p. 333). For example stages two and three retain the short path unit situated in the outside space at the ground floor, (TBH1 5.4, fig. 46, 47, 48, p. 333). Stage three preserves the short path units on either side of this space defined at stage two.

Besides, the short path units are mainly situated on the BF axis and on either side of this axis in all stages. Therefore, a large part of all layouts is seen through small scale movement that mainly covers the central area of the plans throughout the stages. Finally, a large part of the first floor plan is revealed form the triangular unit on the BF axis, (TBH1 5.4, fig. 32, p. 333).

Finally, the most connected units situated on the BF axis are also retained in terms of shape, size and position throughout the stages[23], (TBH1 5.4, fig. 55-63, p. 333). Therefore, the spatial units synchronising the largest number of spatial units in the layout are preserved in terms of shape, size and position. This also means that the units that feature constantly in the majority of visual fields remain the same.

The Invariance-Value index shows that over 50 percent of the spatial units at the first and second floor are visible from the most connected units in all stages, (TBH1 5.11, p. 336). Besides, visual fields produced

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22 The only changes at stage three occur at the back of the ground and second floor plans, (TBH1 5.4, fig. 39, 45, p. 333).

23 The only exception is the most connected unit at the ground floor which moves from the outside space at stage one to the inside at stage two and back to the outside at stage three, (TBH1 5.4, fig. 55-57, p. 333).

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 1 |
| 1ST | 1 | 0.80 | 0.80 |
| 2ND | 1 | 1 | 0.66 |

**Table BH1 5.6**
SYMMETRY GLOBAL SCALE CONVEX SPACES (BF)

(No of sym Global Scale convex spaces/Total no of Global Scale convex spaces, including 'just about' symmetrical Global Scale convex spaces)

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.70 | 0.80 | 0.40 |
| 1ST | 1 | 0.85 | 0.85 |
| 2ND | 1 | 1 | 0.37 |

**Table BH1 5.7**
GLOBAL SCALE - UNIT INDEX

(No of Global Scale Units/Total no of spatial units, excluding spatial units situated in the voids)

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.79 | 1 |
| 1ST | 1 | 0.75 | 0.75 |
| 2ND | 1 | 0.70 | 0.73 |

**Table BH1 5.8**
**SYMMETRY GLOBAL SCALE - UNIT INDEX**

(No of symmetrical Global Scale-Units/Total no of Spatial Units, including 'just about' symmetrical' units) from over 50 percent of spatial units retain contact with these units. At the ground floor this index stays over 0.37 in all stages. There is, thus, a tendency to preserve a large degree of visual synchronisation of spatial units. There is also a tendency to preserve a large number of visual fields in which the most connected units are invariant constituents.

The provision of invariant visual information can be also demonstrated by the large coverage of the plans by Global Scale convex spaces, Global Scale units and overlap units. According to the definition of convexity every spatial point situated on a convex space constantly sees every other point in this space. Therefore, from the Global Scale convex spaces global scale information is constantly offered over a sequence of steps. From the Global Scale units and the overlap units sharing their defining sides there is constant visual access to the same Global Scale convex space or Local Scale convex space to which these units belong[24].

To summarise, the comparative examination of stages shows that spatial transformation constantly preserves certain patterns of spatial articulation. These patterns concern the configurational characteristics of elements, i.e. shape, size and position, their patterns of distribution as well as with the ratio of their numbers to the total number of elements in these layouts. In other words, transformation seems to subject the space in process into the properties of the first stage.

The characteristics of spatial experience resulting from the preservation of these patterns are: a large degree of global scale information, a continuous successive synchronisation of Global and Local Scale convex spaces, a short exploration route extending from back to front at the centre of the plan and visual information that remains invariant over a sequence of steps. These characteristics are stronger in the first floor constructing an exposure of large scale relations from as few positions as possible.

- **Physical properties of spatial articulation**

At stage one every surface of the block is visible in its entirety from the Global Scale convex spaces and Global Scale units that cover the layouts as wholes, (TBH1 5.4, fig. 1, 4, 7, p. 333). At the first and second floor both the outer surfaces and the surfaces of the void are simultaneously seen from the triangular units on the BF axis, (TBH1 5.4, fig. 31, 34, p. 333).

At the following stages the front surface in all floors, the right surface at the first and second floor and the back surface at the first floor are also exposed in full length[25], (TBH1 5.4 fig. 2, 3, 5, 8, 9, p. 333). The Global Scale unit-index indicates that there is a considerable number of visual fields that synchronise

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24 There is also constant visual access to the surfaces defining these spaces. This is something the examination of physical properties in the following part will refer to.

25 This is due to the Global Scale convex spaces which are preserved at these locations.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.78 | 0.81 |
| 1ST | 1 | 0.67 | 0.67 |
| 2ND | 1 | 0.70 | 0.48 |

Table **BH1 5.9**

SYMMETRY SPATIAL - UNIT INDEX, (BF)
(No of symmetrical Spatial Units/Total no of Spatial Units, including 'just about' symmetrical units)

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 0.85 |
| 1ST | 1 | 0.75 | 0.75 |
| 2ND | 1 | 1 | 0.50 |

Table **BH1 5.10**
SYMMETRY SHORT PATH - UNIT INDEX, (BF)

(No of symmetrical Short Path Units/Total no of Short Path Units, including 'just about' symmetrical units)

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.52 | 0.57 | 0.37 |
| 1ST | 0.92 | 0.64 | 0.64 |
| 2ND | 0.92 | 0.75 | 0.50 |

**Table BH1 5.11**
**INVARIANCE - VALUE INDEX,**

(No of spatial units visible from the most connected units/Total no of spatial units, including spatial units situated in the voids) the outer surfaces from distance, (TBH1 5.7, p. 335). This number is higher in the first floor than in the others, (over 85 percent of visual fields throughout the stages, as opposed to 37 percent).

At the first floor there is a simultaneous exposure of a large part of the outer and the inner surfaces constructed from the triangular short path unit at the back of the layout, (TBH1 5.4, fig. 13, 14, TBH1 5.4, fig. 32, p. 333). At the ground and the first floor surfaces are not simultaneously revealed from a single point. However, from the Global Scale convex space at the front of all plans the whole of the front surface, the surfaces of the void and portions of the left and right surfaces are visible at once, (TBH1 5.4 fig. 3, 9, p. 333).

Finally, the continuous network of Global Scale units and overlap units constructs a constant and successive synchronisation of a number of outer and inner surfaces in all floors, (TBH1 5.4, fig. 11, 12, 14, 17, 18, 38, 39, 41, 44, 45, p. 333). These surfaces by being constantly visible and successively synchronised, they become invariant characteristics of a number of visual fields.

Therefore, analysis shows that the preservation of spatial properties carries with it a preservation of physical properties. At the first floor there is a successive exposure of the outer surfaces in full length through peripheral movement and a simultaneous exposure of a large number of physical elements from a single point. At the ground and the second floor a synchronisation of outer and inner boundaries is offered only at the front of the layout. Nevertheless, a successive synchronisation of outer and inner surfaces is provided from the continuous distribution of overlap units in all floors.

- **Geometrical properties of spatial articulation**

At stage one the Global Scale convex spaces, the Global Scale units and the spatial units are symmetrical on the BF axis in all floors, (TBH1 5.4, fig. 1, 4, 7, 10, 13, 16, 37, 40, 43, p. 333). Besides, the short path units, the most connected units and the invariance values are also symmetrically arranged with respect to this axis, (TBH1 5.4, fig. 46, 49, 52, 55, 58, 61, p. 333). The symmetrical distribution of elements belonging to all spatial systems under examination can be also demonstrated by looking at the Symmetry Global Scale convex spaces index, the Symmetry Global Scale-Unit index, the Symmetry Short Path-Unit index and the Symmetry Invariance-Value index, (TBH1 5.6, p. 335, TBH1 5.8, p. 335, TBH1 5.10, p. 336, TBH1 5.12, p. 337).

From stage one to stage three the Symmetry Global Scale convex space index at the ground floor stays 1 in all stages, (TBH1 5.6, p. 335). At the first and second floor this index moves from 1 to 0.80 and 0.66 respectively. Therefore, the organisation of the Global Scale convex spaces either stays symmetrical, (ground floor) or moves to 'just about' symmetry, (first floor) and local symmetry, (second floor).

The Symmetry Global Scale-Unit index at the ground floor moves from 1 at stage one to 0.79 at stage two and 1 at stage three, (TBH1 5.8, p. 335). At the first and second floor this index changes from 1 to

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.76 | 0.59 |
| 1ST | 1 | 0.67 | 0.67 |
| 2ND | 1 | 0.71 | 0.41 |

**Table B 5.12**
SYMMETRY/ INVARIANCE - VALUE INDEX (BF),

(No of symmetrical Spatial Units having identical invariance values / Total no of Spatial Units, including 'just about' symmetrical units and units situated in the voids)

0.75 and 0.73 respectively. Therefore, the Global Scale units are either symmetrically arranged on the BF axis, (ground floor) or move from overall symmetry to 'just about' symmetry, (first and second floor).

The Symmetry Spatial-Unit index at the ground floor moves from 1 to 0.81, (TBH1 5.9, p. 336). At the first and second floor it changes from 1 to 0.67 and 0.48 respectively. Therefore, the distribution of these units changes from overall symmetry to 'just about' symmetry at the ground floor and from overall symmetry to local symmetry at the first and second floor.

The Symmetry Short Path-Unit index moves from 1 to 0.85 at the ground floor and from 1 to 0.75 at first floor, (TBH1 5.10, p. 336). At second floor it changes from 1 to 0.50. Therefore, in the former the distribution of the short path units moves from overall symmetry to 'just about' symmetry. In the latter it changes from overall symmetry to local symmetry.

The majority of the most connected units are either situated on the BF axis or are symmetrical on this axis in all floors, (TBH1 5.4, fig. 55-63, p. 333). The Symmetry Invariance-Value index at the ground floor changes from 1 to 0.59, (TBH1 5.12, p. 337). At the first and second floor this index moves from 1 to 0.67 and 0.41 respectively. Therefore, the organisation of the invariance values moves from overall symmetry to local symmetry in all floors.

Thus, the comparative examination of stages shows that the geometrical properties of spatial articulation in all spatial systems considered by this analysis exhibit overall symmetry or 'just about' symmetry or local symmetry in all stages. In other words, the geometrical properties of each stage either coincide or are close approximations of the geometrical properties of the first stage.

The effects of a geometrical co-ordination of spatial elements on the BF axis seem to be about a geometrical co-ordination of types of visual information. Thus, there is global and local scale visual information offered from symmetrical elements. There are also symmetrical or 'just about' symmetrical visual fields provided from the spatial units located on the BF axis, (TBH1 5.4, fig. 28-36, p. 333), as well as from the spatial units that are symmetrical with respect to this axis, (TBH1 5.5, fig. 1-12, p. 334).

In other words, spatial experience in these layouts seem to be geometrically determined. This means that an underlying geometrical order is built into the structure of visual information that connects close and distant spatial elements together under the co-ordinating role of the BF axis.

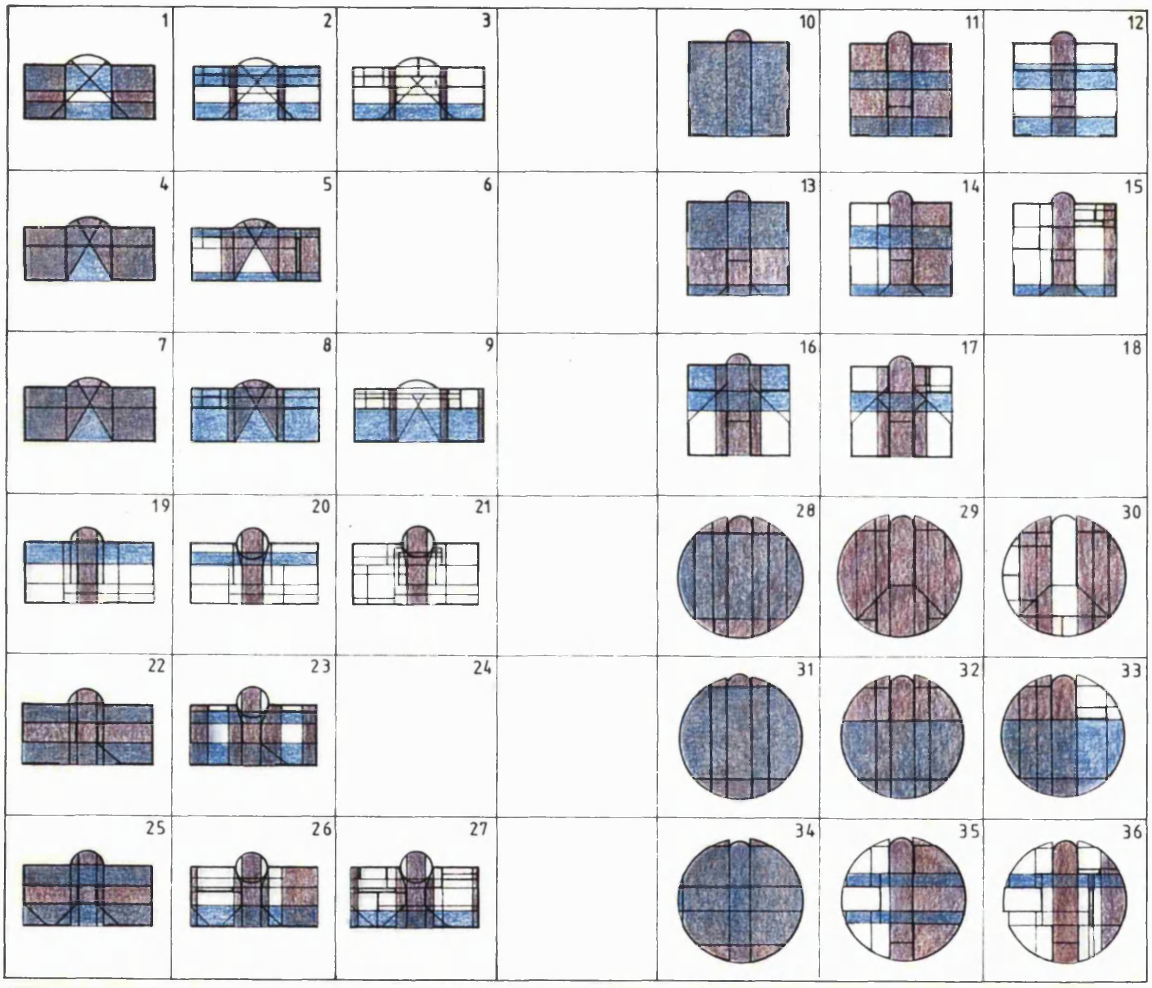

**Table B 5.1 - GLOBAL SCALE CONVEX SPACES**

Comparative examination of Botta's houses

# • COMPARISON ACROSS BOTTA'S HOUSES

At this stage analysis moves to a comparison of all four houses of Botta. The aim is to examine how these houses become intelligible during spatial experience.

The second set of questions that are addressed at this point is :

- Is there a consistent pattern of transformation of spatial articulation? i.e. is there a consistent pattern of occurrence of transformations that associates certain spatial patterns with certain stages?
- Which are the rules that govern this transformation?

Examining the patterns of the transformation process analysis attempts to uncover consistencies in the ways the systems of convex spaces and spatial units develop through the analytic stages. The underlying motive is to reveal whether Botta uses a specific transformation process that consists of identifiable design manoeuvres in terms of elements used, of their locations, their distribution and the stages in which they occur. While this examination looks at how much analytic stages are specific to design changes, the following section investigates the degree to which stages are specific to the properties of the first stage, i.e. the degree to which properties remain invariant in the transformation of the spatial structure.

It should be noted that in the comparative examination of the houses eight tables of figures are used each of which represents the transformation of a specific spatial concept applied by this analysis in all four houses, (TB 5.1-TB 5.8, p. p. 338, 340, 341, 342, 343, 344, 347, 351 ). There are also seven tables of analytic measurements accounting for the transformation of various indexes, (TB 5.9-TB 5.15, p. p. 348, 349, 350). In each of the tables of figures the first floor of BH1 and BH3 and the second floor of BH2 at stage three are not characterised by any changes remaining as defined in stage two. For a more detailed description see Plan Analysis in which these stages are established or see the appendix.

## • THE PATTERNS OF THE TRANSFORMATION PROCESS

### • Global Scale convex spaces, (TB 5.1)

A summary of the patterns of transformation of the Global Scale convex structure is offered here prior to the presentation of each stage. An analytic report of this structure in each stage will follow to provide in detail its development in the analytic sequences.

Looking at the Global Scale convex structure in all houses, it turns out that each of the three stages is specific to particular configuration of Global Scale convex spaces as well as to the locations these spaces take on the plans.

Thus, stage one is associated with the positioning of Global Scale convex spaces on the central geometrical bay, (9/12 plans), on either side of this bay, (9/12 plans), as well as at the back and the front of the plan, (9/12, plans). Stage two is associated with the preservation or the placement of certain Global Scale convex spaces on either side of the central one (9/12 plans), as well as on the right or on either the left and the right sides of the plan, (7/12 plans). Finally, both stages two and three are associated with the preservation of those Global Scale convex spaces running at the front of the layout, (8/12 plans), and the elimination of those extending at the back of the composition.

At this point a parenthesis is opened to enable a detailed description of the characteristics of each stage and of the ways changes occur from one stage to the other. At stage one there is a Global Scale convex space extending at width that coincides with the central geometrical bay in nine out of twelve plans, (9/12), (TB 5.1, fig. 10, 13, 16, 19, 22, 25, 28, 31, 34, p. 338). There is also one, (TB 5.1, fig. 1, 10, 13, 16, 34, p. 338), two, (TB 5.1, fig. 4, 7, 22, 25, p. 338), or three, (TB 5.1, fig. 25, 31, p. 338)[26], Global Scale convex spaces extending at width on either side of this space in eleven plans, (11/12). Finally, there are two Global Scale convex spaces extending at length each of which is situated at the back or at the front[27],in six plans, (6/12), (TB 5.1, fig. 1, 4, 7, 13, 22, 25, p. 338).

In the following stages the central Global Scale convex space at width is retained in all floors of BH2, BH3, and BH4 throughout the stages[28], (TB 5.1, fig. 10-27, 31-36, p. 338). At stage two nine plans, (9/12), are still covered by one, (TB 5.1, fig. 2, 11, 17, 23, 26, p. 338), two, (TB 5.1, fig. 5, 8, p. 338), or three, (TB 5.1, fig. 29, 32, p. 338), Global Scale convex spaces extending at width on either side of the central Global Scale convex space. Some of these spaces stretch from the outer sides to the centre of the plans. Others cover a smaller area of the plan coinciding with the narrow geometrical bays. Finally, seven plans, (7/12), have their right side, (TB 5.1, fig. 5, 14, 35, p. 338), or both their left and right sides, (TB 5.1, fig. 23, 26, 29, 32, p. 338), covered by a Global Scale convex space.

The Global Scale convex spaces extending at length at the back of the composition at this stage are eliminated, (TB 5.1, fig. 11, 14, 17, 29, 32, 35, p. 338)[29]. On the other hand, the one extending at the front of the plan is retained in eight plans, (8/12 plans), (TB 5.1, fig. 2, 5, 8, 11, 14, 23, 26, 32, p. 338).

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26 For a clearer representation of the Global Scale convex spaces at the second floor of BH3 and the first floor of BH4 see also the tables presenting convex spaces analytically on the plans, TBH3 5.1, fig. 17, 18, 19, (p. 359), TBH4 5.1, fig. 10, 13, (p. 342).

27 There is also a wide GS c-space covering both the front and the back of the layout in three out of twelve plans, (TB 5.1, fig. 10, 28, 34).

28 The only exception is the ground floor of BH4 at stage three where the central GS c-space is not preserved, (TB 5.1, fig. 3, p. 338).

29 The only exception is BH1 where this space is retained in all floors, (TB 5.1 fig. 2, 5, 8, p. 338).

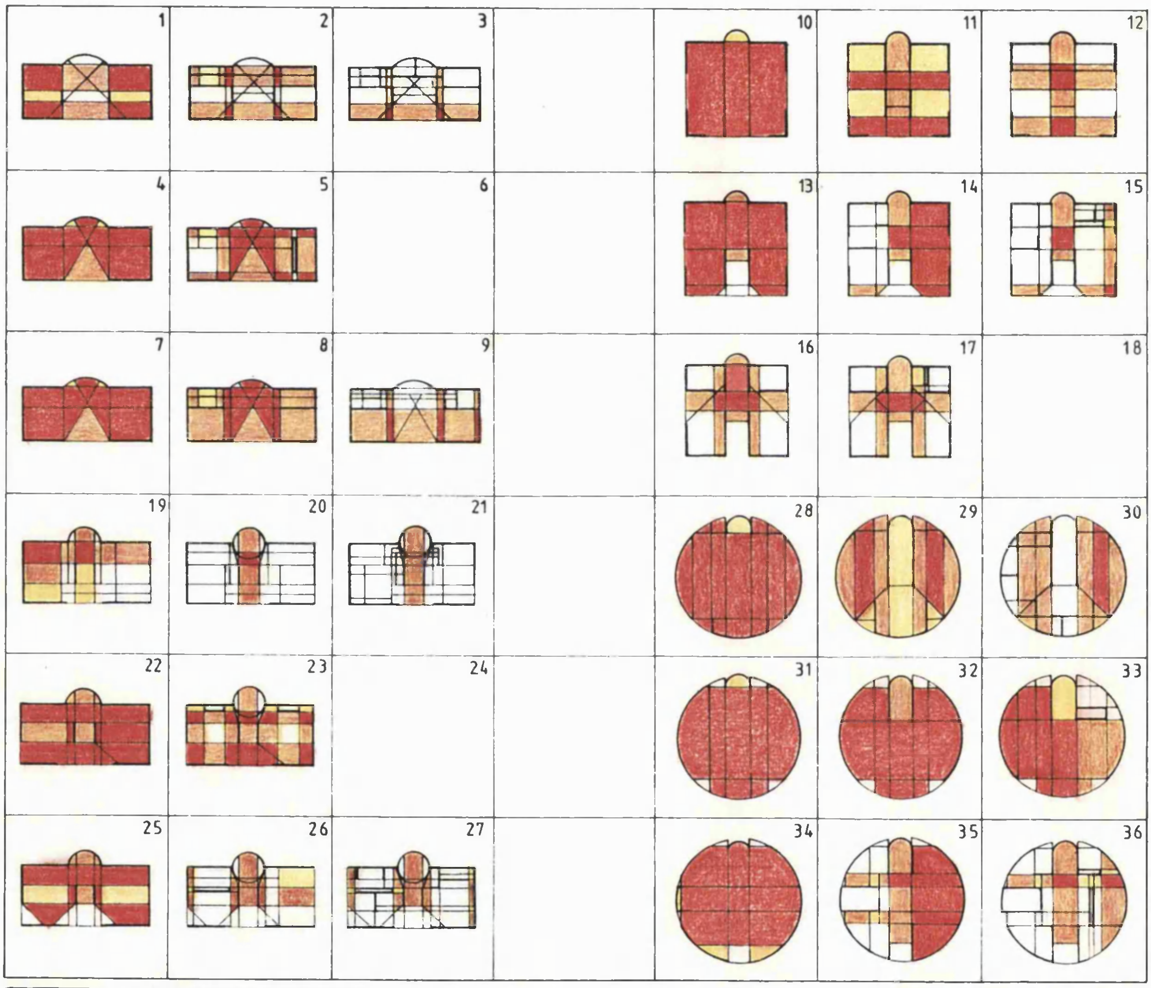


**Table B 5.2** - **GLOBAL SCALE UNITS**
Comparative examination of Botta's houses

At stage three the configuration of the Global Scale convex spaces at width stays as defined at stage two in most plans[30]. Thus, there is one, (TB 5.1, fig. 3, 9, 17, 23, 27, p. 338) or two, (TB 5.1, fig. 5, 30, p. 338) Global Scale convex spaces on either side of the central Global Scale convex space[31] in seven plans[32], (7/12). There is also one space extending at the right side, (TB 5.1, fig. 5, 9, 15, 36, p. 338) or both the left and the right sides of the layout, (TB 5.1, fig. 23, 27, p. 338), in six plans, (6/12).

The configuration of these spaces at length remains as defined at stage two[33]. Therefore, there is a Global Scale convex space running next to the front surface of the block in eight plans, (8/12), (TB 5.1, fig. 3, 5, 9, 12, 15, 23, 27, 32, p. 338).

Closing the parenthesis, analysis returns to the initial observation that summarised the patterns of development of the Global Scale convex structure. It can be argued that this development is about an association between certain stages, certain transformations in the configuration of the Global Scale convex spaces and certain positions these spaces occupy on the plans.

- **Global Scale units, (TB 5.2)**

According to the definition of Global Scale units established by this analysis, these belong to Global Scale convex spaces. Therefore, the pattern of transformation of these spaces carry with them a pattern of transformation of their overlap units. In this way, the association of stages with Global Scale convex spaces observed above results in an association of these stages with Global Scale units.

Thus, at stage one these units extend from left to right at the front and the back of the layout and from back to front at the centre and the sides in all plans, (TB 5.2, fig. 1, 4, 7, 10, 13, 22, 25, 28, 31, 34). The only exceptions are the ground floor of BH3 and the second floor of BH2, (TB 5.2, fig. 19, 16). In the former there are no such units at the front right side of the plan. In the latter Global Scale units extend from left to right at the centre and from back to front at the centre and the sides of the BF axis.

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30 The only exceptions are the ground floor of BH4 in which the GS c-spaces extending on the left side of the central one are reduced from three to two, (TB 5.1, fig. 30, p. 338), the ground floor of BH2 and the first floor of BH4 in which these spaces are eliminated, (TB 5.1 fig. 12, 33, p. 338).

31 Or on either side of the BF axis for BH1.

32 In the calculations of plans at stage three the plans that are not characterised by any changes remaining as defined at stage two are also taken into consideration.

33 The only exceptions is the Global Scale convex space extending at the back of the ground and second floor of BH1, (TB 5.1, fig. 3, 9, p. 338) which is removed as well as the space extending at the front of the second floor of BH3 the width of which is reduced, (TB 5.1, fig. 27, p. 338).

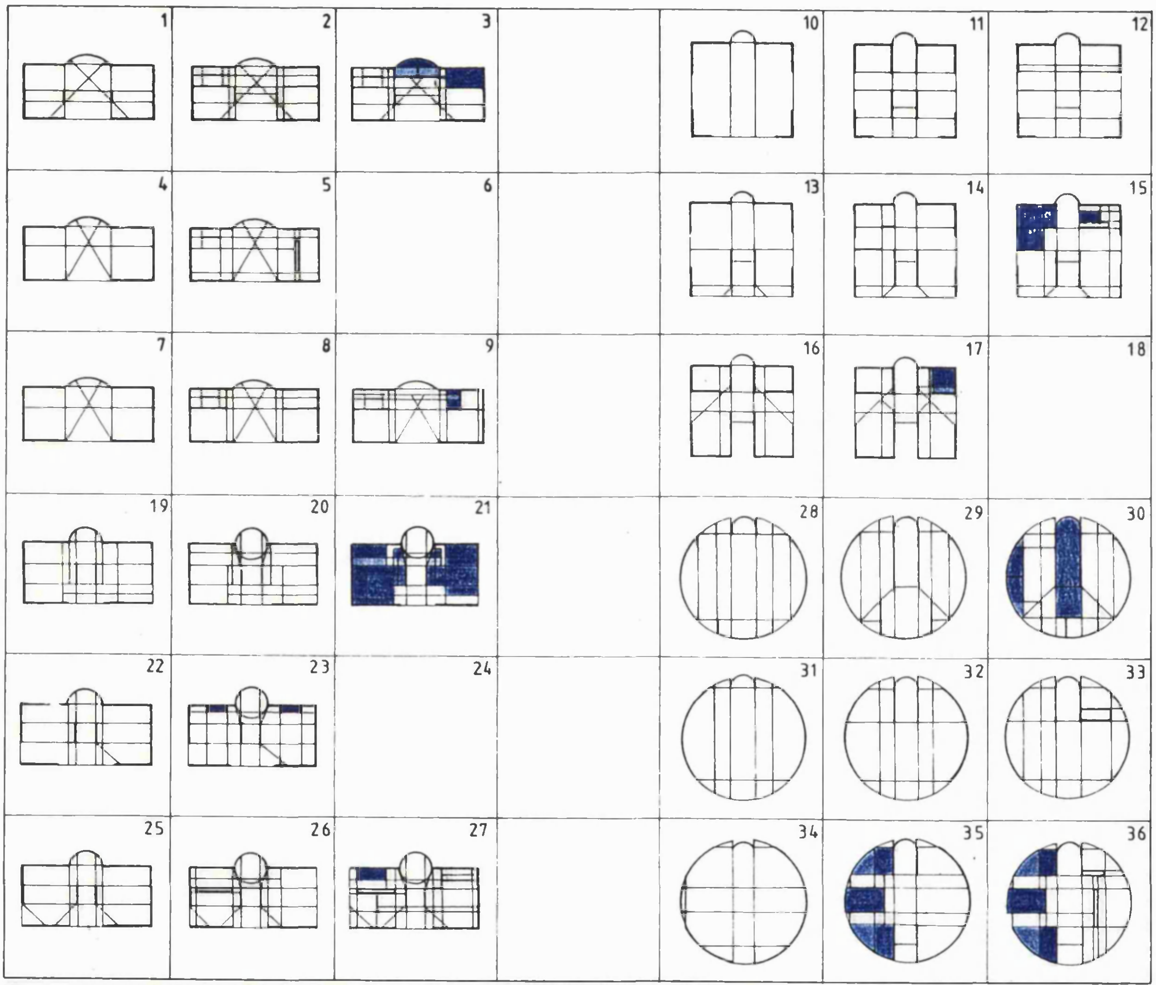


Table **B 5.3** - **LOCAL SCALE CONVEX SPACES NOT OVERLAPPING WITH GLOBAL SCALE CONVEX SPACES**

Comparative examination of Botta's houses

At stage two the Global Scale units stretch from back to front at the centre in all plans, (TB 5.2, fig. 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, p. 340)[34]. They also extend in the same direction on either side of the BF axis in nine plans, (9/12), (TB 5.2, fig. 2, 5, 8, 11, 17, 23, 26, 29, 32, p. 340), or on the right side, (TB 5.2, fig. 5, 14, 35, p. 340), or both the left and right sides in seven plans, (7/12), (TB 5.2, fig. 23, 26, 29, 32, p. 340). Finally, there are Global Scale units stretching from left to right at the front of the composition in six plans, (6/12), (TB 5.2, fig. 2, 5, 8, 11, 23, 32, p. 340). The ones extending at the back at stage one are eliminated at this stage.

At stage three the configuration of these units at width stays mainly as defined in the previous stages. Thus, there are units extending at the centre in nine plans, (9/12), (TB 5.2, fig. 5, 12, 15, 17, 21, 23, 26, 33, 36, p. 340). There are also units on either side of the BF axis in eight plans, (8/12), (TB 5.2, fig. 3, 5, 9, 17, 23, 27, 30, 33, p. 340), and units on the right or both the left and right side of the layout in eight plans, (8/12), (TB 5.2, fig. 5, 9, 15, 23, 27, 30, 33, 36, p. 340). Finally, the organisation at length is also similar to the one at stage two retaining Global Scale units that extend along the front surface in six plans, (6/12), (TB 5.2, fig. 3, 5, 9, 12, 23, 33, p. 340).

Therefore, stage one is associated with a complete coverage of the plans with Global Scale units. Stage two is associated with the preservation of these units that are centrally placed extending at width as well as with the placement of units on either side of the BF axis and next to the right or both sides of the plan. Finally, stage three is about the preservation of those Global scale units extending at width of the configuration at stage two and the elimination of those extending at length at the back of the layout. It is also associated with the preservation of those units running at length at the front of the plan.

These observations reconfirm what was initially suggested about the interrelation between the Global Scale convex spaces and their overlap units, i.e. there is an association of certain stages with certain transformations and certain locations of the Global Scale units on the plans.

- **Global Scale convex spaces overlapping with Local Scale convex spaces, (TB 5.3)**
At stage one and two every Local Scale convex space overlaps with a Global Scale convex space. The only exceptions are the second floor of BH2, the first floor of BH3 and the second floor of BH4 at stage two, (TB 5.3 fig. 17, 23, 35). The units belonging to Local Scale convex spaces that do not overlap with Global Scale convex spaces in these floors are situated either at the left back side or at the left back and front side, (BH2 and BH4) or at the back of the plan, (TBH3). At stage three these units occupy either the left or the right back side, (TB 5.3, fig. 3, 15, 27), or the right back side, (TB 5.3 fig. 17), or the left

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34 There are cases like the first and second floor of BH2, the second floor of BH3 and BH4 in which these units do not stretch to the front of the composition because of the existence of a void at this location. However, if the parameter of the void as being not permeable is ignored then Global Scale units exists also in these location.

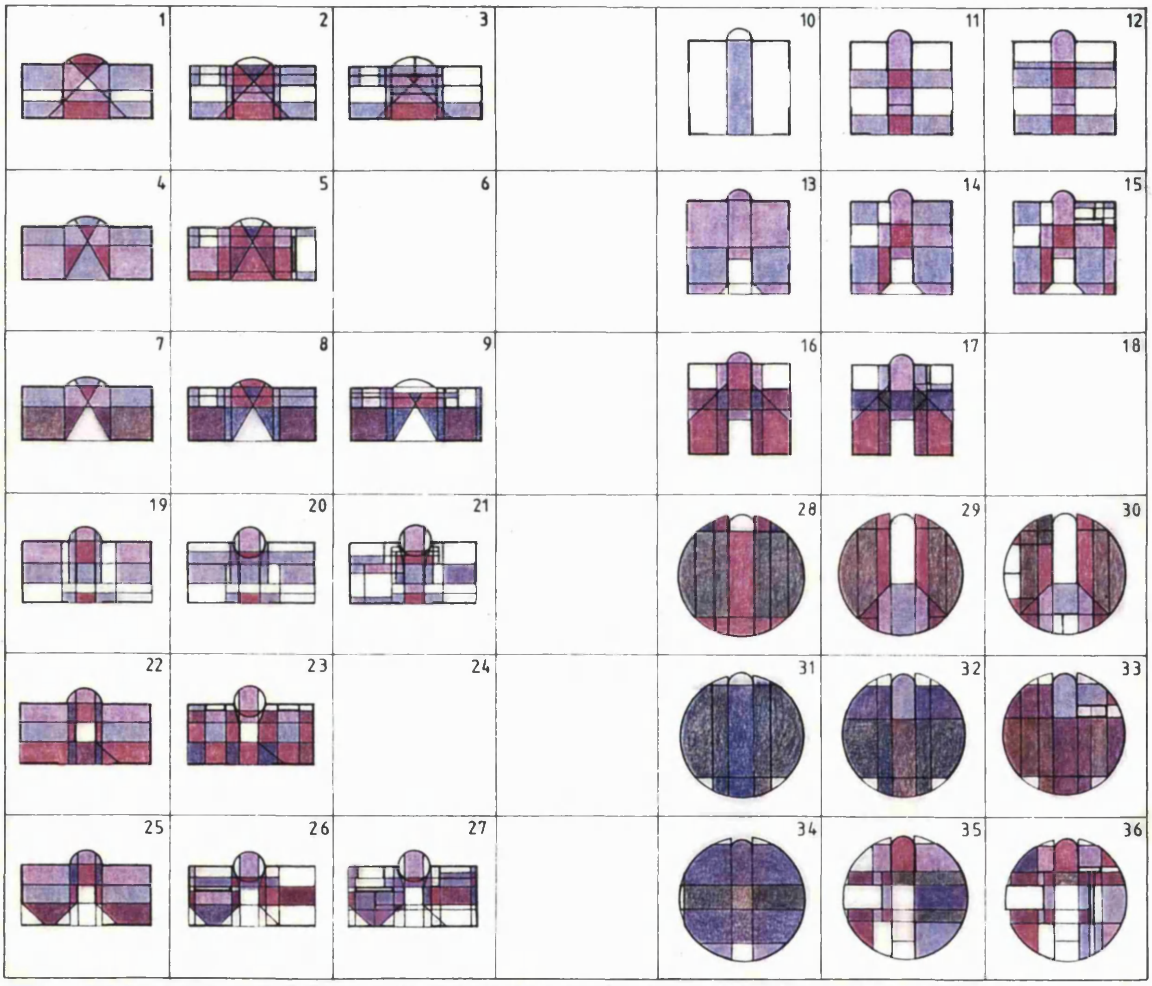


Table **B 5.4** - **OVERLAP UNITS**

Comparative examination of **Botta's** houses back and front side (TB 5.3 fig. 35, 36, p. 341) or both the left and back sides, (TB 5.3 fig. 21, p. 341) or the left side and the centre of the plan, (TB 5.3 fig. 30, p. 341).

Therefore, there is an association of stages one and two with the absence of units not belonging to Global Scale convex spaces and of stage three with the existence of these units and with their distribution on the sides of the plan.

- **Overlap units, (TB 5.4)**

At stage one the overlap units spread over a large part of the area of the plans, (TB 5.4, fig. 1, 4, 7, 13, 6, 19, 22, 25, 28, 31, 34). At stages two and three these units are removed either from the back left and right corners, (TB 5.4, fig. 11, 12, 16, 17, 20, 21, 23), or from all four corners of the layout, (TB 5.4, fig. 20, 21, 26, 27). Thus, there seems to be an association between stages two and three and the elimination of overlap units from certain positions.

Looking at the Global Scale convex spaces, the Global Scale units and the overlap units it turns out that the largest part of the first floor in BH1, BH3 and BH4 is almost completely covered by these elements in all stages, (TB 5.1, p. 338, TB 5.2, TB 5.4, fig. 4, 5, 22, 23, 31, 32, 33, p. 342). In the rest of the floors there is a smaller coverage of the plans by these elements, (TB 5.1, fig. 2, 3, 8, 9, 12, 17, 20, 21, 26, 27, p. 338). Therefore, there seem to be a consistent pattern of association between the patterns of distribution of elements and specific horizontal levels.

- **The short path units, (TB 5.5)**

At stage one there is a single cluster of short path units that share their defining sides situated at the centre of the layout, (TB 5.5, fig. 4, 7, 10, 13, 16, 22, 25, 31, p. 343)[35]. At stages two there is a reduction in the size and an increase in the number of these units, (TB 5.5, fig. 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, p. 343). There is also a change in their patterns of distribution. Thus, there is central cluster of units and one or more individual units that spread along the periphery, (TB 5.5, fig. 5, 14, 17, 20, 23, 26, 35, p. 343). At stage three the decrease in the size and the increase in the numbers of the short path units is accentuated further, (TB 5.5, fig. 3, 9, 12, 15, 21, 27, 30, 33, 36, p. 343).

To summarise, stage one is associated with a cluster of units at the centre of the plan. Stages two and three are related to a cluster on the centre and individual units located next to the periphery of the layout. In other words, there is an association between stages, short path units and their patterns of distribution.

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35 The only exceptions are the ground floor of BH1, BH3 and BH4 , (TB 5.5, fig. 1, 19, 28, p. 343), as well as the second floor of BH4, (TB 5.5, fig. 34, p. 343), in which the short path units occupy separate positions.

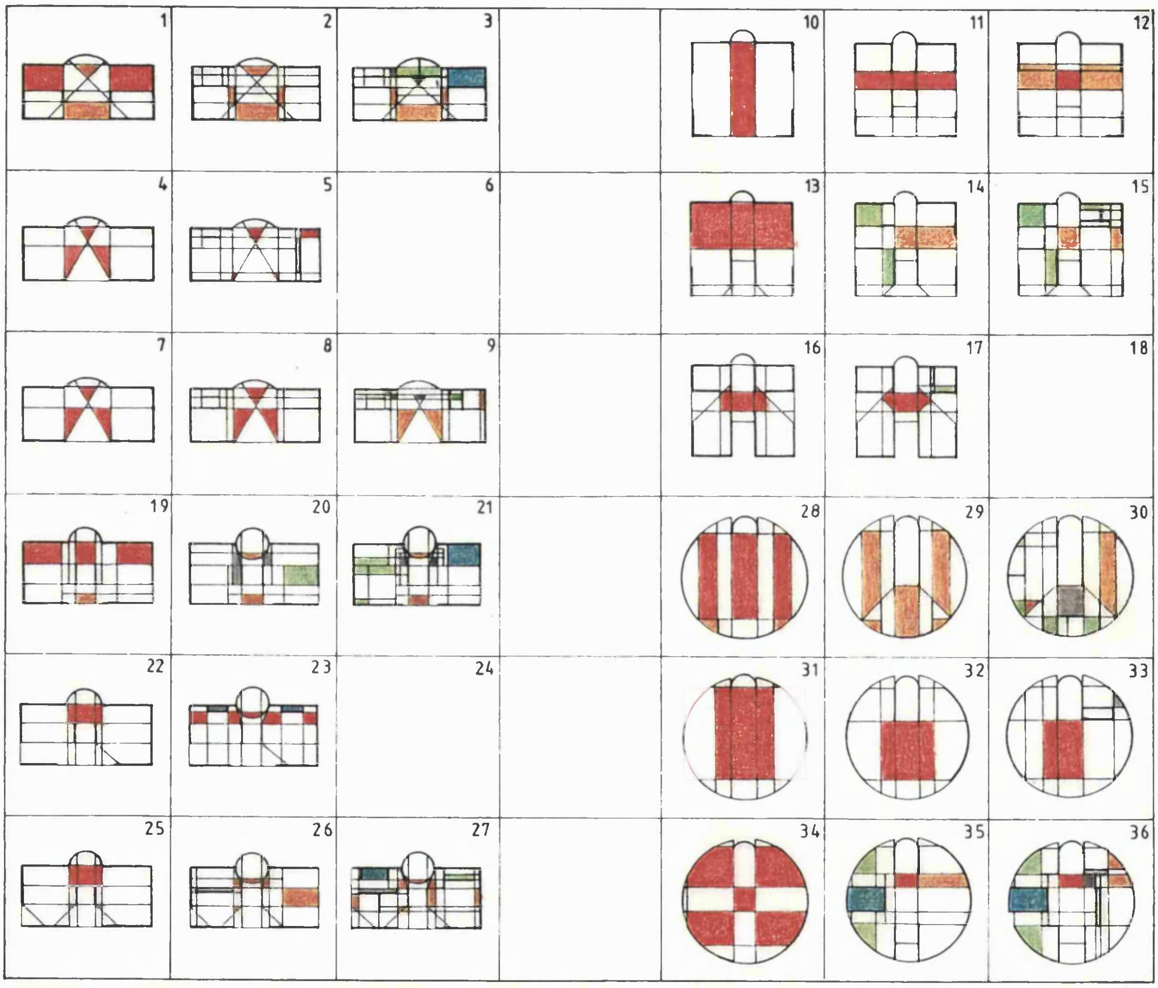


**Table B 5.5 - SHORT PATH UNITS**
Comparative examination of Botta's houses

- **The most connected units, (TB 5.6)**

At stage one the most connected units are situated on the BF axis or on either side of this axis or on both the BF axis and on its either side in ten plans[36], (10/12), (TB 5.6, fig. 1, 4, 7, 10, 13, 16, 25, 28, 31, 34, p. 344). At stages two and three the pattern of distribution of these units stays the same in nine, (9/12), (TB 5.6, fig. 2, 5, 8, 11, 14, 17, 20, 29, 32, p. 344), and six plans, (6/12), (TB 5.6, fig. 3, 5, 12, 17, 21, 36, p. 344), respectively. Therefore, there is a consistent pattern that associates certain stages with certain transformations regarding the pattern of distribution of these units.

House 4 is a different case than the rest of the houses in the sense that there is a higher concentration of most connected units at the first and second floor at stage one, (TB 5.6, fig. 31, 34, p. 344), the ground and first floor at stage two, (TB 5.6, fig. 29, 32, p. 344), and the first floor at stage three, (TB 5.6, fig. 33, p. 344). In these floors the most connected units share their defining sides extending from the sides to the centre of the plan. Besides, their area is much larger than that of the units in the rest of the houses. Nevertheless, the patterns of distribution of most connected units in relation to stages remain as described above. The effects of these differences in the spatial experience of these layouts will be discussed in the following section presenting the properties of transformation of these units

*To summarise, the comparative examination of stages shows that there is a consistent association between certain stages with certain transformations and certain locations the elements occupy on the plans. There is also an association between certain patterns of distribution of spatial components and certain floors.*

*Thus, there seems to be a specific compositional logic characterising the transformation process. This logic employs specific strategies concerning the occurrence, the positions and the configurational patterns of spatial elements.*

- **THE RULES OF THE TRANSFORMATION PROCESS**

Having completed the examination of how stages relate to configurational patterns, the analysis looks at the spatial properties and their physical and geometrical characteristics in each stage with a view to identify the degree to which these remain invariant during the transformation.

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36 The identification of the most connected units and the calculations of the invariance values and of the Invariance-Value index takes into consideration the spatial units situated inside the voids. These units are 'seen' but cannot 'see' other units because they are not permeable. The reason for including them is that the analytical significance of the most connected units and of the invariance values lies mainly on the degree to which spatial units are seen from other units rather than on the degree to which they see other units.

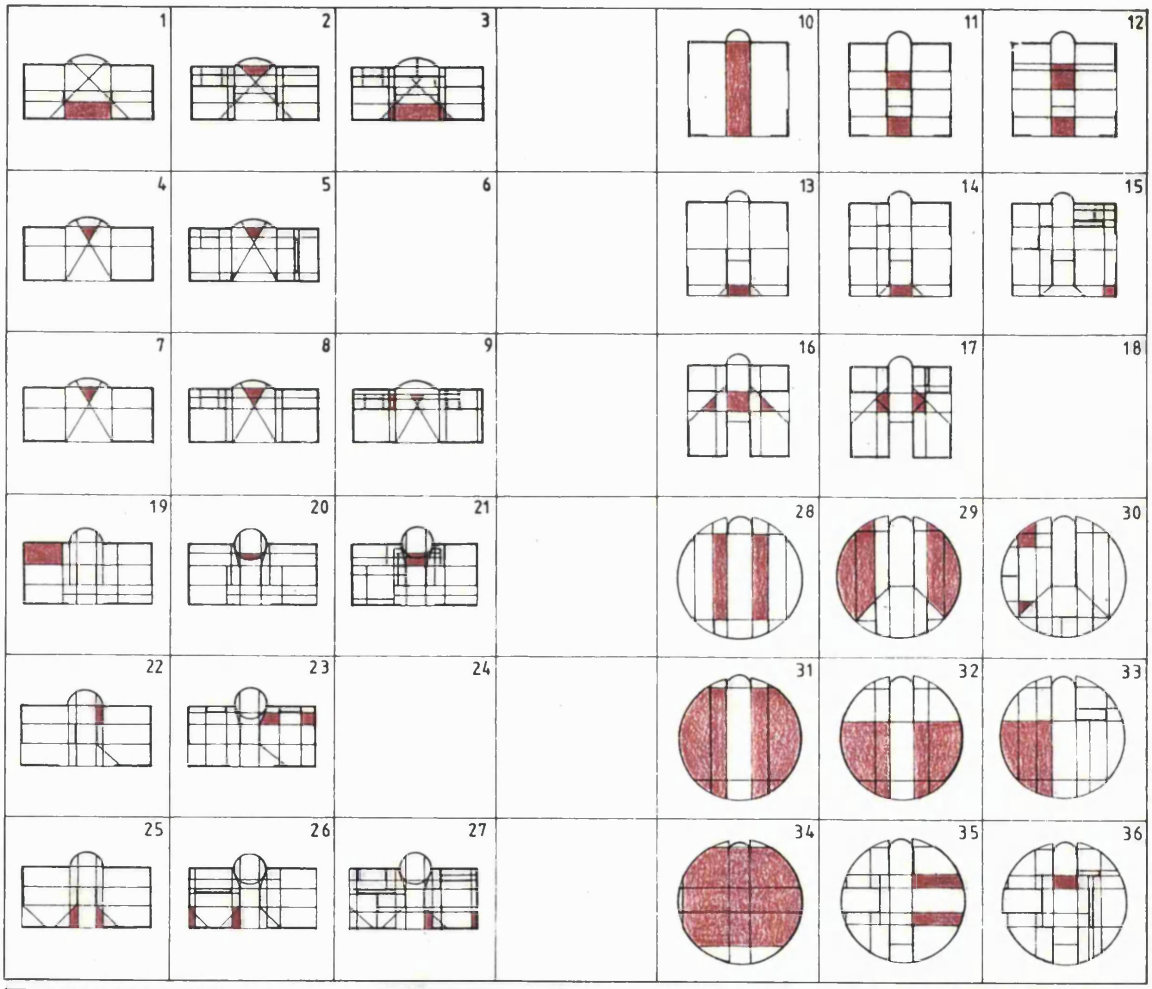


Table **B 5.6** - **MOST CONNECTED UNITS**
Comparative examination of Botta's houses

• **SPATIAL PROPERTIES**

• **STAGE ONE**

At stage one visual fields constantly reach throughout the plans in two directions based on a complete coverage of plans by Global Scale convex spaces and Global Scale units, (TB 5.1, p. 338, TB 5.2, fig. 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, p. 340).

The majority of the layouts are revealed as wholes from the periphery of the central short path unit, (TB 5.7, fig. 10, 13, 16, 22, 25, 28, 31, 34, p. 347). The ground, the first and the second floor of BH1 as well as the ground floor of BH3 are not exposed from a single location, (TB 5.7, fig. 1, 4, 7, 19, p. 347). However, at the first and second floor of BH1 the central short path unit reveals the largest part of the plans, (TB 5.7, fig. 4, 7, p. 347). On the other hand, the ground floor of BH1 and BH3 become visible as wholes through movement that progresses from back to front at the centre of the plan and from left to right at the rear, (TB 5.5, fig. 1, 19, p. 343).

The Invariance-Value index of the most connected units is above 0.70 in nine plans[37], (9/12), (TB 5.14, p. 350). There is, thus, a great degree of visual synchronisation of spatial units provided from the most connected units. Besides, these units are invariant characteristics of the majority of visual fields.

• **STAGES TWO AND THREE**

Analysis showed that the Global Scale convex space extending at width at the centre and the one extending at length at the front of the plans are preserved throughout the stages in the majority of the plans, (TB 5.1 fig. 10-36, p. 338). Certain Global Scale convex spaces extending at width on either side of the central one and those at the left or at the right or at both the left and the right side of the plans are also retained. *Thus, a large degree of global scale information and the positions from which this is offered are preserved. This information remains invariant over a number of steps taken inside the Global Scale convex spaces.*

At stage three the Global Scale-Unit index remains over 0.40 in ten plans[38], (10/12), (TB 5.10, p. 349). *Therefore, there is a tendency to maintain a large number of visual fields that reach the outer sides of the plan.*

Analysis suggested that a certain number of overlap units remain the same in terms of shape, size, position and overlap value in all stages, (TB 5.4, fig. 1-36, p. 342). These units cover a large part of the

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37 These are the first and second floor of BH1, the ground and first floor of BH2, the first and second floor of BH3 and all floors of BH4.

38 These are the ground and first floor of BH1, all floors of BH2, the first and second floor of BH3 and all floors of BH4.

plans sharing their defining sides. A large number of these units are Global Scale overlap units and Global-Local Scale overlap units, (TB 5.2, fig. 1-36, p. 340). Thus, *spatial transformation retains a successive synchronisation of global and local scale convex spaces in all stages*[39].

This can be also observed by looking at TB 5.3, (p. 341), presenting the spatial units that belong to convex spaces that do not intersect with a Global Scale convex space. This table shows that there are very few spatial units that have this property. In other words, in these layouts the majority of spatial units are either Global Scale overlap units or Local Scale overlap units or are few steps away from these units.

As it was suggested before similalry to the Global Scale convex spaces which remain constantly visible from every spatial unit situated inside them, Global-Local Scale convex spaces and Local Scale convex spaces are also recurrent elements of visual fields produced from their spatial units. Therefore, the subdivision of convex spaces into a number of continuous overlap units indicates *that visual fields retain an amount of visual information that remains constant over a number of steps.*

Analysis also showed that each stage preserves certain short path units defined at the previous stage. Therefore, particular areas of the plan are revealed from the same short path routes. The exposure of a large part of the first floor of BH1, BH3, BH4 and the ground and second floor of BH2 from the central short path unit is also retained, (TB 5.7, fig. 5, 12, 17, 23, 33, p. 347).

The ground and second floor of BH1 are mainly revealed through a small scale path that covers the central area of the plan extending from the back to the front[40], (TB 5.5, fig. 3, 9, p. 343). The ground floor of BH4 is also seen through small scale observation that concentrates at the front of the layout, (TB 5.5 fig. 30, p. 343). *Therefore, there is a tendency to maintain a short and specific exploration route in the majority of the plans, (8/12 plans). This route is either minimised in a single location or consists of a small number of locations.*

The distribution of the most connected units at stage two remains as defined at stage one, i.e. these units are situated either on the BF axis, or on this axis and on its either side or on the axis and one of its left or right sides, (TB 5.6, fig. 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, p. 344). At stage three these units retain the same distribution pattern in six plans, (TB 5.6 fig. 3, 5, 12, 17, 21, 36, p. 344). Therefore, this pattern is not retained by the majority of the plans in all stages.

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39 In certain cases the overlap value of some units is such that simultaneous information about six to twelve or even fifteen convex spaces is constantly offered, (TB 5.4, fig. 5, 9, 17, 23, 33, 36, p. 342).

40 The short path units that are distanced from this route reveal only a small portion of these layouts. Thus, the largest area is seen from the short path route mentioned above.

However, the Invariance-Value index remains over 0.50 in eight plans[41], (8/12), (TB 5.14, p. 350). *This shows that although the positions from which visual synchronisation is offered and the positions that are recurrent characteristics of visual fields change, there is tendency to preserve a large degree of synchronisation and of information invariance.*

- **SPATIAL PROPERTIES AND INTELLIGIBILITY**

The comparative examination of spatial systems shows that transformation retains certain spatial elements, their configurational patterns and the positions of these elements on the plans. *In this way, the rules of spatial articulation in each stage are subjected to the rules of the first stage.*

*Thus, transformation is constantly directed towards specific patterns of spatial exposure.* These patterns are as follows: Simultaneous exposure of large and small scale relations from a single position or from a short observation route. Constant successive synchronisation of global and local scale spatial relations. Global and local scale information that stays invariant over a number of steps. Visual synchronisation of a large number of units and recurrence of certain units in a large number of visual fields.

The synchronisation of global and local scale relations from a single and from a large number of positions suggests that it is easy to grasp the layout as a whole within a short time. This grasping can be assisted by a large degree of visual information that stays persistent in the progression of spatial movement. Encountering global scale views and recurring patterns of information one would seem to find these layouts intelligible almost at once.

Analysis also showed that spatial transformation is directed towards an association between certain patterns of exposure, certain spatial locations and certain floors. Therefore, global and local scale information is always offered from the same areas. Besides, the first floor is revealed as a whole from the same unit, while a certain part of the rest of the floors are seen from the same short route[42]. This generates a repetitive pattern of information transmission along the horizontal and the vertical direction that contributes to the intelligibility of each layout as well as of the house as a whole.

The first floor of all houses seems to reveal the largest amount of information from the centre of the plan. The expansive views from these locations seem to enable a static appreciation, i.e. a situation in which one can simply stand on a single location and observe a large part of the volume with its excavated areas intruding into its space. In the ground and second floor a similar situation is encountered at the front of the layout through the glazed surfaces of the voids. Large views reaching from the left outer surface to the right one expose a spatial stratification with alternating layers of inside and outside space. The

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41 These are the first and second floor of BH1, all floors of BH2, the first and second floor of BH3 and the first and second floor of BH4.

42 This consists of the short path units clustering around the BF axis.

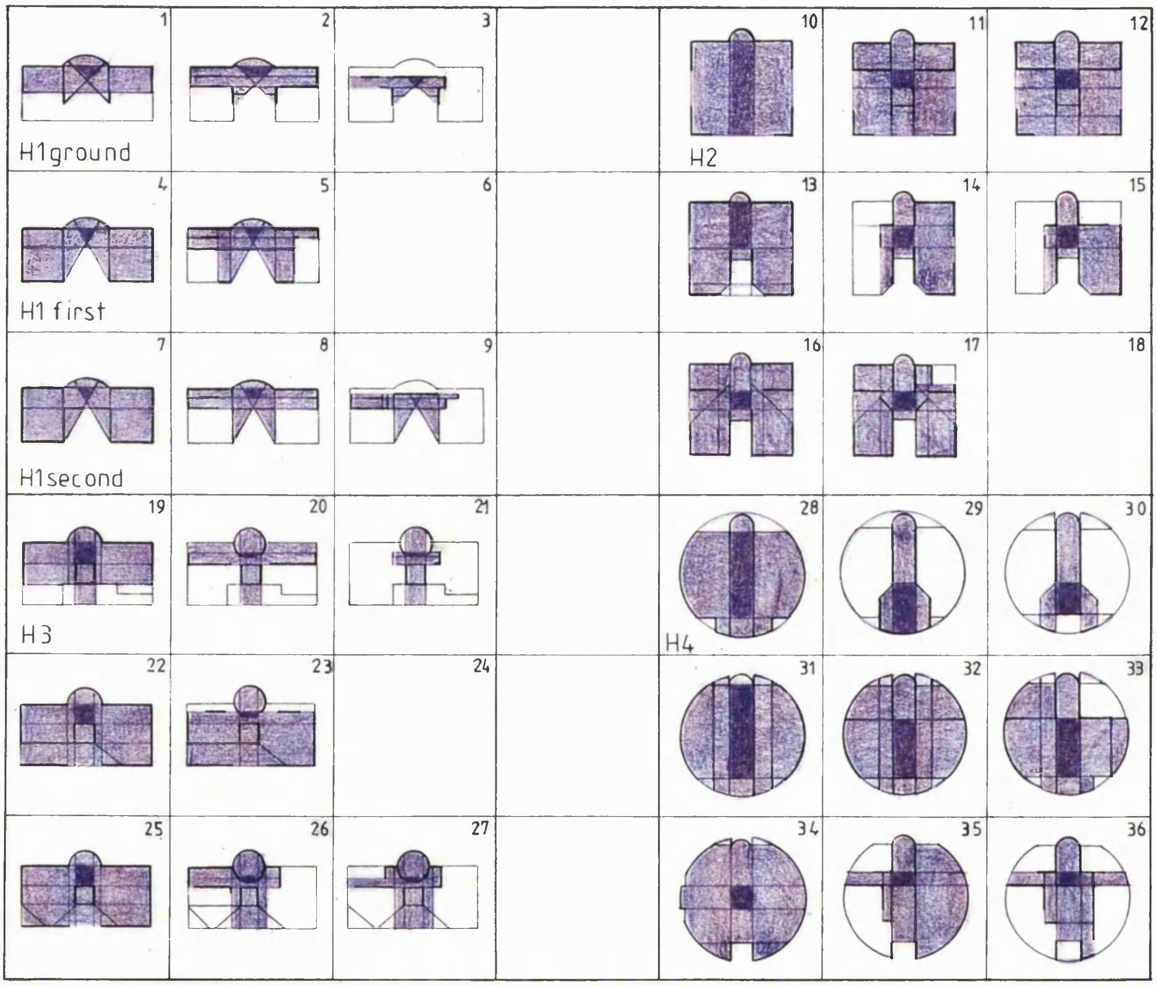


Table **B 5. 7** - **VISUAL FIELDS FROM CENTRAL SHORT PATH UNITS**
Comparative examination of Botta's houses

circulation areas at the back regardless of the amount of overlap they accommodate, offer long linear views that are repetitively intersected by linear views along the other direction. A lattice of wide and narrow visual fields is, thus, constructed in these floors. The former offer a static awareness of global and local scale relations, whereas the latter is more dynamic encouraging an observer to move. However, this dynamic condition is exhausted as soon as the visitor steps into the front of the layout.

- **Physical properties of spatial articulation**

Moving to the physical properties the patterns of constitution of visual fields by the outer and the inner surfaces in these layouts are examined. The aim is to see whether there is an underlying presence of particular surfaces in the majority of visual fields that stays constant throughout the stages. In this way, the role of these surfaces as physical integrators of spatial elements can by identified.

At stage one each of the outer surfaces is seen in full length from any spatial point due to a full coverage of plans by Global Scale convex spaces and Global Scale units, (TB 5.1, p. 338, 5.2, fig. 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, p. 340). From the central unit all surfaces of the block, and every other surface in the layout are simultaneously seen, (TB 5.7, fig. 4, 7, 10, 13, 16, 22, 25, 28, 31, 34). *At this stage the layouts are experienced as single volumetric enclosures bounded by a continuous surface and excavated at the centre.*

In the following stages the front surface, (TB 5.1, fig. 2, 3, 5, 8, 9, 11, 12, 14, 15, 23, 26, 27, 32, 33, p. 338), the right surface, (TB 5.1, fig. 5, 9, 15, 30, 36, p. 338), or both the left and the right surfaces of the volume, (TB 5.1, fig. 23, 27, p. 338) are exposed as physically continuous elements from the Global Scale convex spaces extending next to them. Besides, a large number of visual fields that synchronise the outer surfaces from distance are constructed expressed by the high value of the Global Scale-Unit index, (over 0.40, TB 5.10, p. 349).

A large part of the first floor of BH1, BH3 and BH4 and the ground and second floor of BH2 is exposed from a single unit. Therefore, synchronisation of a large part of the outer and the inner surfaces is constructed from this unit, (TB 5.7, fig. 5, 12, 17, 23, 33).

In the rest of the floors there is not a single position from which a simultaneous awareness of all physical elements is offered. However, a large number of overlap units are Global Scale overlap units and Global-Local Scale overlap units, (TB 5.2, fig. 2, 3, 8, 9, 14, 15, 26, 27, 29, 30, 32, 33, 35, 36, p. 340). In this way, there are many spatial locations from which a synchronisation of global and local scale relations is provided.

Besides, as TB 5.3, (p. 341), showed the majority of spatial units belong to convex spaces that overlap with the Global Scale convex spaces. Thus, there is a constant successive synchronisation of the outer and the inner surfaces produced from almost every location in these layouts.

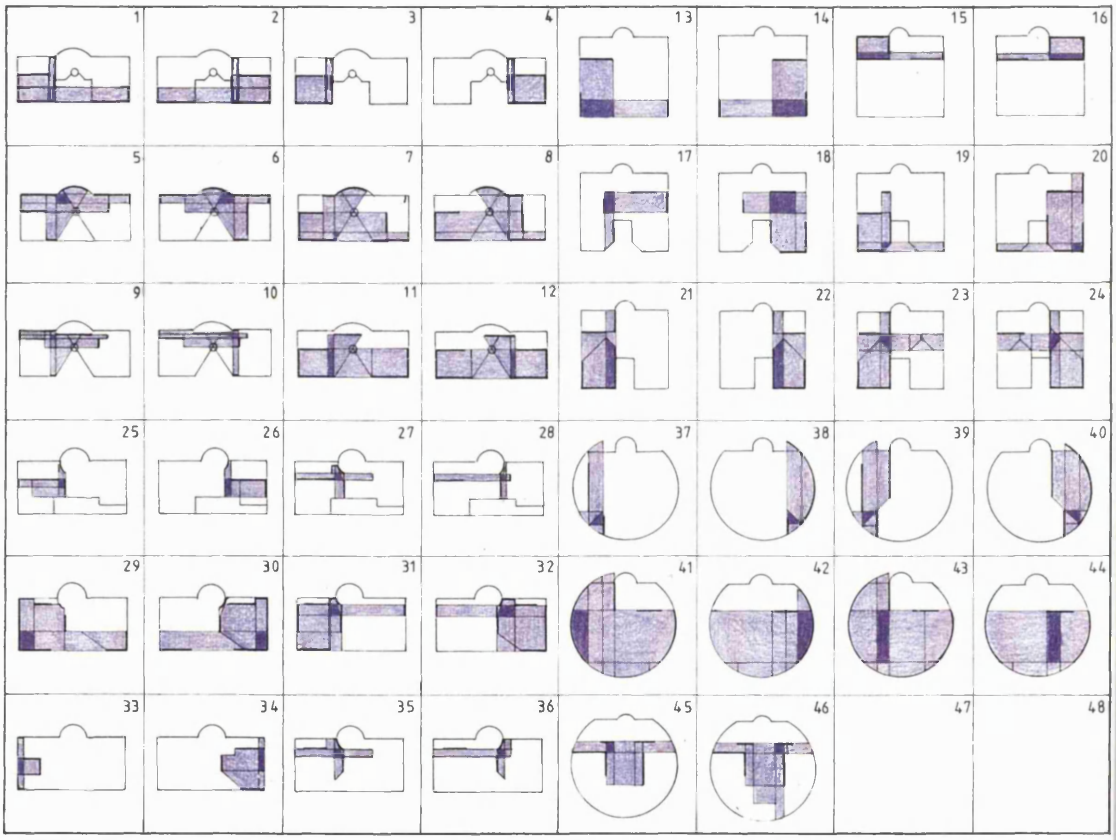


Table B 5.8 - VISUAL FIELDS FROM SYMMETRICAL SPATIAL UNITS
Comparative examination of Botta's houses

## • PHYSICAL PROPERTIES AND INTELLIGIBILITY

The comparative analysis of houses shows that *the preservation of the spatial properties of stage one carries with it a preservation of physical properties. Similarly to the spatial relations there is a tendency to preserve certain patterns of exposure of physical relations.*

These patterns are: Visual access to the whole length of certain outer surfaces through the Global Scale convex spaces extending next to them. Visual access to the outer surfaces from distance through a considerable number of Global Scale units. A simultaneous synchronisation of the outer and the inner surfaces constructed from the a single short path unit. A successive synchronisation of these surfaces constructed from a continuous network of overlap units the majority of which are Global Scale overlap units and Global-Local Scale overlap units.

In other words, there is a constant simultaneous or successive synchronisation of global and local scale physical relations offered from every location in these layouts. *This synchronisation means that the outer surfaces enter every visual field binding close and distant spatial elements together.* The physical integration of spaces by binding surfaces seems to contribute to the intelligibility of the layouts.

Similarly to the spatial properties the preservation of patterns of exposure of surfaces from specific locations associates these patterns with specific places and specific horizontal levels. Repetition in the ways types of information are transmitted enhances the intelligibility of each level as well as of the houses as wholes.

## • GEOMETRICAL PROPERTIES OF SPATIAL ARTICULATION

From the physical properties analysis moves next to the geometrical properties of spatial patterns. The aim is to see whether, similarly to the physical interconnection of spaces by integrating surfaces, there is a geometrical interconnection of visual fields by integrating axes. To do so, analysis focuses on the geometrical patterns of distribution of spatial elements and on the ways these evolve in the analytic stages. This is achieved by looking at the analytic measurements accounting for the ratio of symmetrical elements to the total number of elements in the layouts, i.e. the Symmetry Global Scale convex space index, the Symmetry Global Scale-Unit index and so on.

The Symmetry Global Scale convex space index at stages one and two is 1 in ten and eight plans respectively, (10/12, 8/12), (TB 5.9, p. 349). At stage three it is over 0.80 in eight plans[43], (8/12). Therefore, the organisation of these spaces moves from overall symmetry to 'just about' symmetry.

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43 These are the ground and first floor of BH1, the ground and second floor of BH2, all floors of BH3 and the ground floor of BH4.

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 1 | 1 | 1 | 1 | 1 | 1 | 0.50 | 1 | 1 | 1 | 1 | 0.80 |
| **1ST** | 1 | 0.80 | 0.80 | 1 | 0.50 | 0.50 | 1 | 1 | 1 | 1 | 1 | 0.25 |
| **2ND** | 1 | 1 | 0.66 | 1 | 1 | 1 | 1 | 0.60 | 1 | 0.33 | 0.50 | 0.50 |

Table **B 5.9**
**SYMMETRY GLOBAL SCALE CONVEX SPACES, (BF)**
(No of symmetrical Global Scale convex spaces / Total no of Global Scale convex spaces, including 'just about' symmetrical Global Scale convex spaces).

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 0.70 | 0.80 | 0.40 | 1 | 1 | 0.68 | 0.50 | 0.38 | 0.11 | 1 | 1 | 0.67 |
| **1ST** | 1 | 0.85 | 0.85 | 1 | 0.40 | 0.52 | 1 | 0.76 | 0.76 | 1 | 1 | 0.83 |
| **2ND** | 1 | 1 | 0.37 | 0.76 | 0.73 | 0.73 | 1 | 0.58 | 0.48 | 1 | 0.71 | 0.40 |

Table **B 5.10**
**GLOBAL SCALE - UNIT INDEX**
(No of Global Scale-Units / Total No of spatial units, excluding spatial units situated in the voids).

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 1 | 0.79 | 1 | 1 | 1 | 1 | 0.84 | 1 | 1 | 1 | 1 | 0.52 |
| **1ST** | 1 | 0.75 | 0.75 | 1 | 0.83 | 0.25 | 0.68 | 0.76 | 0.76 | 1 | 1 | 0.86 |
| **2ND** | 1 | 0.70 | 0.73 | 1 | 1 | 1 | 0.88 | 0.64 | 0.48 | 0.46 | 0.33 | 0.58 |

Table **B 5.11**
**SYMMETRY GLOBAL SCALE - UNIT INDEX, (BF)**
No of symmetrical Global Scale units / Total no of spatial units, excluding spatial units situated in the voids)

The symmetry Global Scale-Unit index at stage one is 1 in nine plans, (9/12), (TB 5.10, p. 349). At stage two it is over 0.71 in nine plans[44], (9/12), Finally at stage three this index is over 0.52 in seven plans[45], (7/12). Therefore, the distribution of these units, moves from overall symmetry to 'just about' symmetry and local symmetry. 'Just about' symmetry and local symmetry governing the distribution of these systems means that global scale information is transmitted from a large number of symmetrical Global Scale convex spaces and Global Scale units in all stages.

The Symmetry Spatial-Unit index at stage one is 1 in eight plans, (8/12), (TB 5.12, p. 350). At stage two it is over 0.70 in eight plans[46], (8/12). Finally, at stage three this index is over 0.48 in eight plans[47], (8/12), (TB 5.12, p. 350). The organisation of spatial units moves from overall symmetry to 'just about' symmetry and local symmetry in terms of shape, size, position and overlap value. Therefore, visual information is revealed from symmetrical spatial units. Besides, the same number of convex spaces are simultaneously seen from symmetrical overlap units.

The first floor of BH2, the ground and second floor of BH3 and the second floor of BH4 appear less orderly having a Symmetry Spatial-Unit index that is below 0.43. However, it is only at the first floor of BH2 that spatial units display a weak pattern of symmetry, (Symmetry Spatial-Unit index: 0.14). In the rest of the floors there is a considerable number of units are symmetrical on the BF axis, (Symmetry spatial-Unit index: 0.38, 0.43 and 0.34 respectively).

At stage one the distribution of the short path units is characterised by overall symmetry on the BF axis, (TB 5.13, p. 350). At stages two and three the Symmetry Short Path-Unit index is over 0.66 in nine plans[48], (9/12), and over 0.50 in seven plans[49], (7/12). Therefore, the organisation of these units moves from overall symmetry to local symmetry. Thus, a large part of the layout as a whole is exposed from a unit the geometrical centre of which is covered by the BF axis. Besides, certain areas of the layout are seen from symmetrical short path units.

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44 These are all floors of BH1, the ground and second floor of BH2, the first floor of BH3 and the ground and first floor of BH4.

45 These are the first floor of BH3, all floors of BH2 the first floor of BH3 and the ground and first floor of BH4.

46 These are all floors of BH1, the ground and second floor of BH2, the ground and first floor of BH3 and the ground and first floor of BH4.

47 These are all floors of BH1, the ground and second floor of BH2, the first floor of BH3 and the ground and first floor of BH4.

48 These are all floors of BH1, the ground and second floor of BH2, the ground and first floor of BH3 and the ground and first floor of BH4.

49 These are the all floors of BH1, the ground and second floor of BH2, the first floor of BH3 and the ground floor of BH4.

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 1 | 0.78 | 0.81 | 1 | 1 | 1 | 0.88 | 0.90 | 0.38 | 1 | 1 | 0.50 |
| **1ST** | 1 | 0.67 | 0.67 | 1 | 0.20 | 0.14 | 0.78 | 0.87 | 0.87 | 1 | 1 | 0.58 |
| **2ND** | 1 | 0.70 | 0.48 | 1 | 0.73 | 0.73 | 0.87 | 0.37 | 0.43 | 0.30 | 0.10 | 0.34 |

Table B 5.12
**SYMMETRY SPATIAL - UNIT INDEX, (BF)**
(No of symmetrical spatial units/Total number of spatial units, Including 'just about symmetrical' units).

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 1 | 1 | 0.85 | 1 | 1 | 1 | 1 | 0.66 | 0.44 | 1 | 1 | 0.71 |
| **1ST** | 1 | 0.75 | 0.75 | 1 | 0.25 | 0.20 | 1 | 1 | 1 | 1 | 1 | 0.33 |
| **2ND** | 1 | 1 | 0.50 | 1 | 0.83 | 0.83 | 1 | 0.50 | 0.33 | 1 | 0.20 | 0.16 |

Table B 5.13
**SYMMETRY SHORT PATH - UNIT INDEX, (BF)**
(No of symmetrical short path units/Total number of short path units, Including 'just about' symmetrical' units).

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 0.52 | 0.57 | 0.37 | 1 | 0.53 | 0.50 | 0.42 | 0.48 | 0.45 | 0.70 | 0.38 | 0.35 |
| **1ST** | 0.92 | 0.64 | 0.64 | 1 | 0.57 | 0.52 | 0.73 | 0.55 | 0.55 | 0.80 | 0.73 | 0.77 |
| **2ND** | 0.92 | 0.75 | 0.50 | 0.65 | 0.66 | 0.66 | 0.71 | 0.80 | 0.58 | 0.92 | 0.55 | 0.47 |

Table B 5.14
**INVARIANCE VALUE INDEX**
(No of spatial units visible from the most connected unit/Total number of spatial units, Including spatial units situated in the voids).

The distribution of the most connected units at stage one is also characterised by overall symmetry on the BF axis in ten plans, (10/12), (TB 5.6, fig. 1, 4, 7, 10, 13, 16, 25, 28, 31, 34, p. 344). At stage two the majority of the short path units are either situated on the BF axis or they are symmetrical on the BF axis in terms of shape, size and position, (9/12 plans), (TB 5.6, fig. 2, 5, 8, 11, 14, 17, 20, 29, 32, p. 344). At stage three six plans retain the symmetrical organisation of the most connected units, (TB 5.6, fig. 3, 5, 12, 17, 21, 36, p. 344). In these cases a synchronisation of spatial units is constructed from geometrically significant locations or from locations that are equivalent on the axis. In the rest of the plans, (TB 5.6, fig. 15, 23, 27, 30, 33, p. 344), this synchronisation is not geometrically determined.

The Symmetry Invariance-Value index is 1 at stage one in eight plans, (8/12), (TB 5.15, p. 351). At stages two and three it is over 0.67 in seven plans[50], (7/12) and over 0.41, in five plans[51], (5/12), respectively. In the rest of the plans it is below 0.28. Therefore, the distribution of the invariance values at stages one and two displays overall symmetry and local symmetry respectively. Thus, the same number of spatial units are synchronised from symmetrical units as well as symmetrical units appear in the same number of visual fields. At stage three most of the plans display weak patterns of local symmetry.

It turns out that whereas most of the spatial systems are characterised by 'just about' symmetry or strong patterns of local symmetry, the distribution of the most connected units as well as of the invariance values on the plan deviates from these patterns in a large number of plans, (six and seven plans respectively). These deviations will be discussed in the next part examining the effects of symmetrical/asymmetrical disposition of elements in spatial experience and intelligibility.

- **GEOMETRICAL PROPERTIES AND INTELLIGIBILITY**

The geometrical organisation of spatial systems moving from overall symmetry, to 'just about' symmetry or local symmetry shows that *there is a close association between the geometrical properties of each stage and the geometrical properties of the first stage.*

A symmetrical disposition of spatial elements constructs a constant association between certain patterns of visual exposure and symmetrical positions. There are also symmetrical or almost symmetrical visual fields constructed from the spatial units situated on the BF axis, (TB 5.7, fig. 3, 5, 9, 12, 17, 21, 23, 27, 30, 33, 36, p. 347). Besides, there are symmetrical or almost symmetrical visual fields released from symmetrical locations. For example in fig. 1, 2, in TB 5.8, (p. 348), the visual fields provided from the rectangular spatial units are symmetrical on the BF axis. The same phenomenon characterises those

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50 These are the all floors of BH1, the ground and second floor of BH2 and the ground and first floor of BH4.

51 These are all floors of BH1 and the ground and second floor of BH2.

| | BH1 | | | BH2 | | | BH3 | | | BH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 1 | 0.76 | 0.59 | 1 | 1 | 1 | 0.73 | 0.45 | 0.27 | 1 | 1 | 0.07 |
| **1ST** | 1 | 0.67 | 0.67 | 1 | 0.36 | 0.28 | 0.40 | 0.27 | 0.27 | 1 | 1 | 0.13 |
| **2ND** | 1 | 0.71 | 0.41 | 1 | 0.83 | 0.83 | 0.87 | 0.30 | 0.17 | 0.69 | 0.21 | 0.16 |

Table **B 5.15**
**SYMMETRY INVARIANCE-VALUE INDEX, (BF)**
(No of symmetrical spatial units having identical invariance values / Total number of spatial units, Including 'just about' symmetrical' units)

constructed from the rectangular units in figures 3 and 4. As this table shows every plan has units that offer visual information that is identical or almost identical with the one released from equivalent units on the other side of the axis, (see also fig. 5-6, 7-8, 11-12, 15-16, 23-24, 31-32 and so on, TB 5.8 fig. 1-46, p. 348). Thus, geometrical regularity co-ordinates global scale spatial and physical relations seen at once, (from the units on the BF axis) as well as global and local scale relations seen at different spatial and temporal moments, (from those that occupy separate positions that are symmetrical on this axis).

The examination of the spatial and the physical structure pointed out that there is a repetitive association between visual fields and certain locations. Analysis of the geometrical properties of this structure shows that there is also a repetitive association between symmetrical visual fields and symmetrical locations.

*Repetition and symmetry built into the system of visual information shows that spatial experience in these layouts is geometrically determined.* An observer encountering a repetitive pattern of symmetrical portions of surfaces and spaces from adjacent and from distant areas can grasp how these elements group themselves under the co-ordinating role of BF axis. *Therefore, the geometrical properties of spatial organisation aid the intelligibility of the spatial and the physical system.*

However, a number of parameters that challenge overall symmetry exist. One parameter is the distribution of spatial elements based on 'just about' symmetry and local symmetry. Thus, not every position has an equivalent one on the other side of the axis. Not every visual field is repeated as one moves from one space to the next, from the one half of the building to the other. For example in fig. 25 and 26 in TB 5.8, (p. 348), both visual fields consists of a linear section extending from back to front and a wider section that extends from the left or the right side of the plan to the centre. However, whereas the linear parts are identical the wide ones are slightly different.

The deviations from the symmetrical pattern occur mainly at the entry and the bedroom level, (see also fig. 27-28, 33-34, 37-38 in TB 5.8, p. 348). Thus, in these floors certain areas are turned into individual episodes introducing some differentiation and variety into the sequences of regularised and homogenised visual fields.

Another parameter that challenges overall symmetry is symmetry in terms of one space characteristic and asymmetry in terms of another. As analysis suggested convex spaces and spatial units are symmetrical in terms of shape and position but asymmetrical in terms of size. For analytical purposes the size deviation from symmetry is ignored. However, the subtle size differences amongst these elements can be captured during spatial experience.

Finally, a third parameter is the distribution of the most connected units and of the invariance values. It was suggested that from stage one and two to stage three these units or some of these units move from the BF axis or from a symmetrical distribution on this axis to its left or its right side in six plans, (6/9 plans), (TB 6.6, fig. 9, 15, 23, 27, 30, 33, p. 344). It was also suggested that the Symmetry Invariance Value index drops below 0.28 in seven plans, (TB 5.15, p. 351). In this respect, the geometrical properties of the most connected units and of the invariance values of the rest of the units are not fully preserved at this stage. Therefore, symmetry preservation in terms of one kind of spatial properties is accompanied by symmetry breaking in terms of another.

To see the effects of an interaction between a geometrical pattern of information transmission and a pattern that deviates from symmetry, the first floor of BH4 is examined. In this layout the unit on the BF axis offers an almost symmetrical visual field, (TB 5.7, fig. 33, p. 347). From the most connected units lying on the left of this unit, (TB 5.6, fig. 33), the visual field ceases to be symmetrical covering also a smaller area of the plan, (TB 5.8, fig. 41, p. 348). This is because the staircase space is removed from vision. However, from this position the number of spatial units visible is larger than the ones from the central unit, (17 as opposed to 13). Therefore, from the former the layout offers a larger degree of information regarding the interconnections amongst its spatial elements. From the latter it offers a larger degree of information regarding its area and symmetrical ordering.

The interaction between global scale information in terms of spatial connections and global scale information in terms of symmetry constructs degrees of differentiation in spatial experience. This differentiation acts as a stimulus to discover spatial characteristics that are subtler than the obvious symmetrical and repetitive visual fields. In Plan Analysis it was suggested that deviations from an overall logic enhance the symmetrical pattern. This is because they act against an automated reception of information produced by the constant application of symmetry. Attention is activated and drawn to symmetry through symmetry breaking. Therefore, trying to fit the deviations into an overall pattern a viewer becomes more attentive as his mental processes are forced to review the situation and re-enact the symmetrical pattern.

At this stage analysis completes the comparative examination of Botta's houses. Before progressing to Le Corbusier a brief reminding of the conclusions reached is offered with a view to summarise the argument and connect with the section that follows. This examination shows that a large degree of visual synchronisation and of recurring patterns of information transmission enable an observer to understand Botta's houses almost at once. Besides, the physical integration of spaces by the outer and the inner surfaces and the regularised visual fields enhance the intelligibility of his layouts.

The analysis of Le Corbusier's plans in the previous chapter offered some insights in relation to the ways his houses become intelligible during spatial experience. It suggested that the configurational complexity of his plans expresses that a similar kind of complexity might be experienced from the ground. In this respect, it is expected that the results of the following section will be fundamentally different from those summarised above.

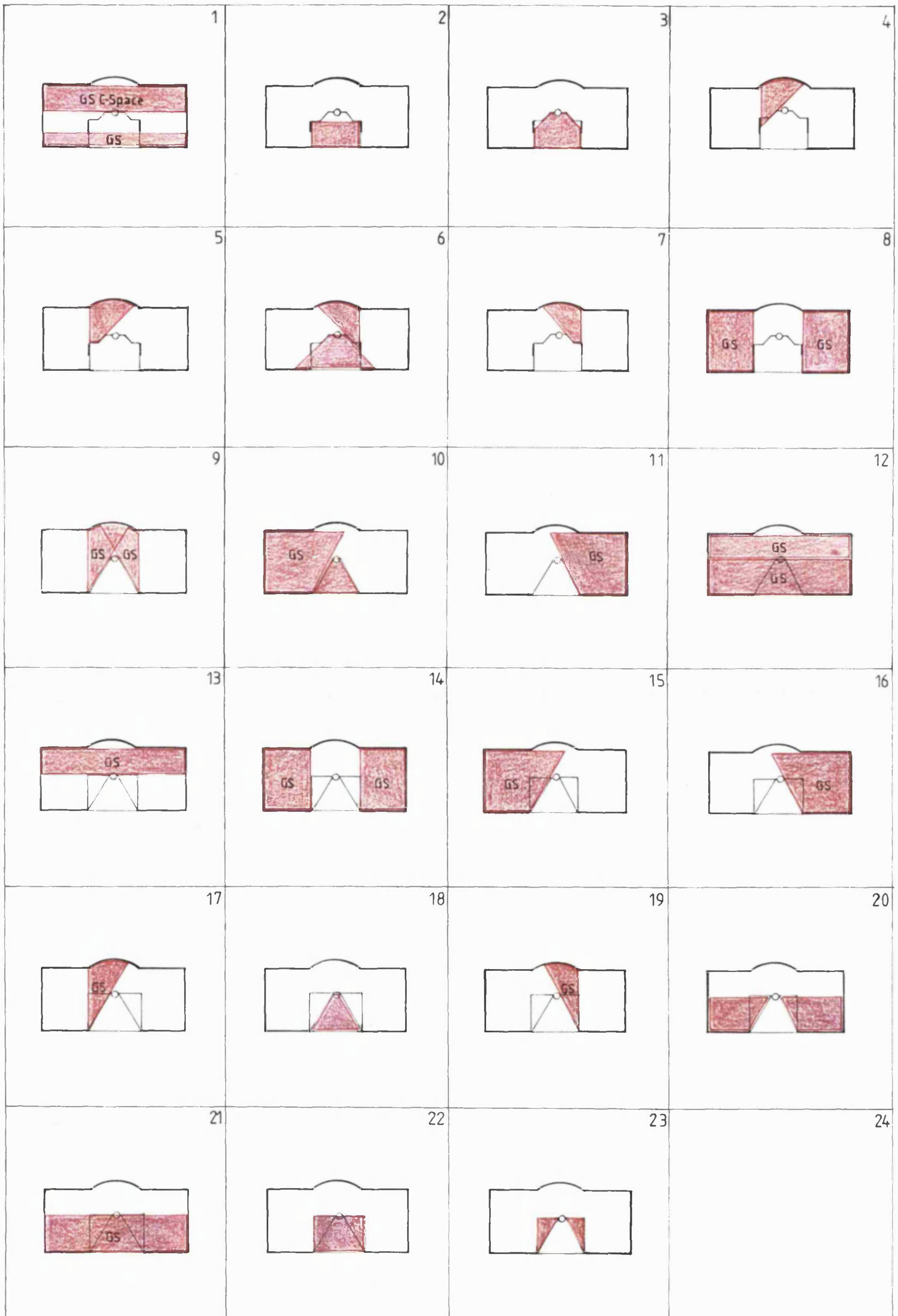


Table **BH1 5.12** - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

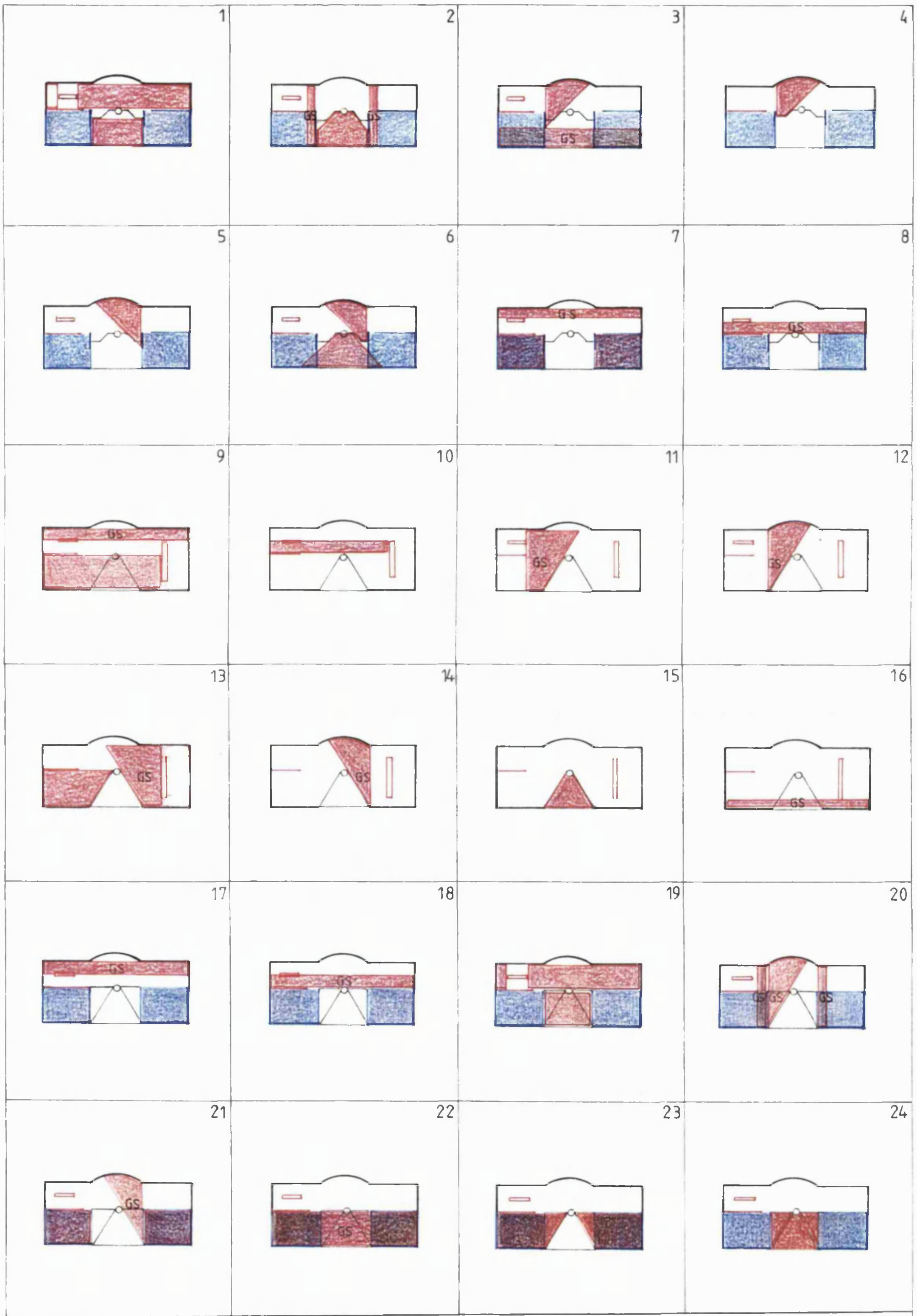


Table **BH1 5.13** - Stage Two

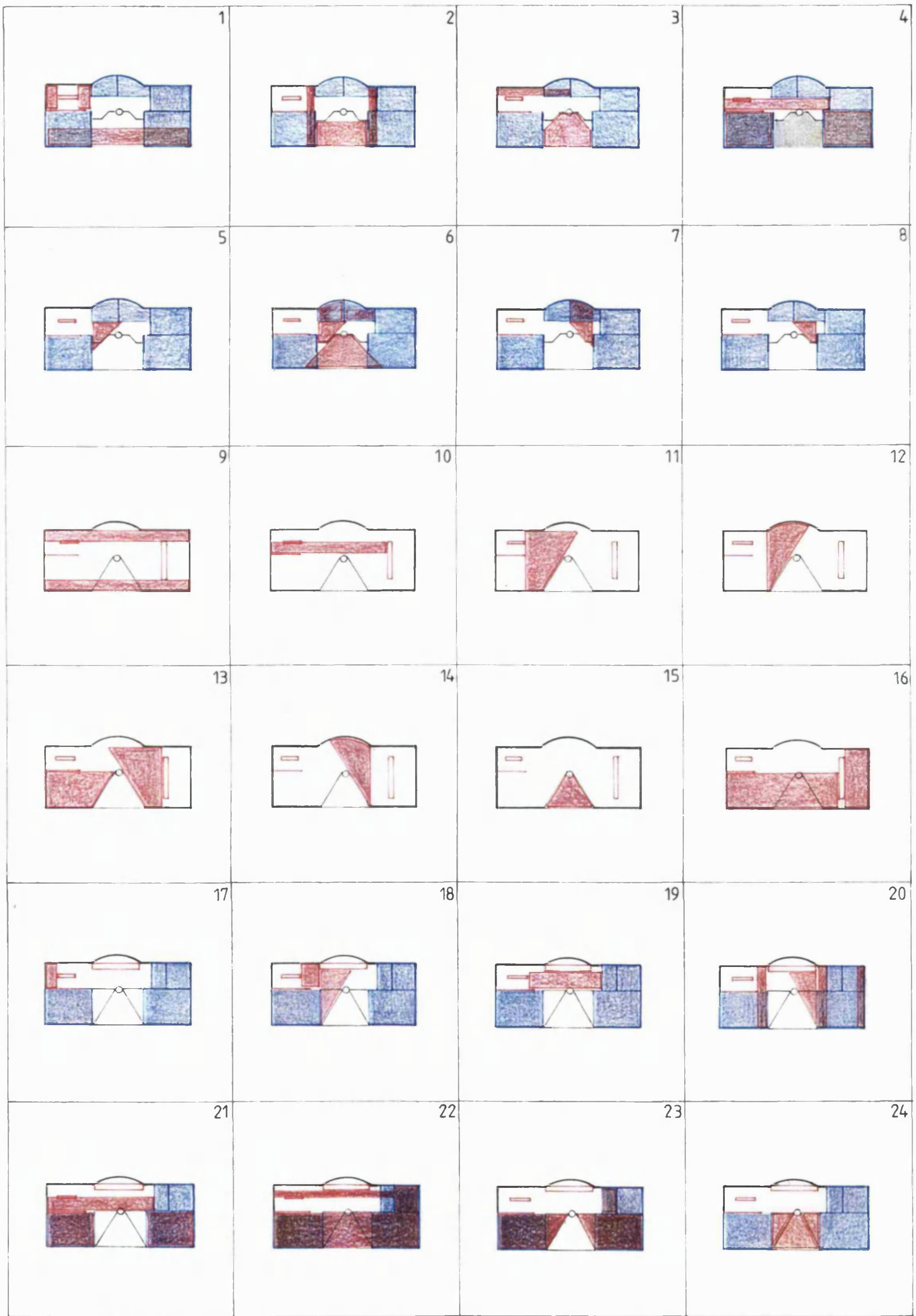


Table **BH1 5.14** - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

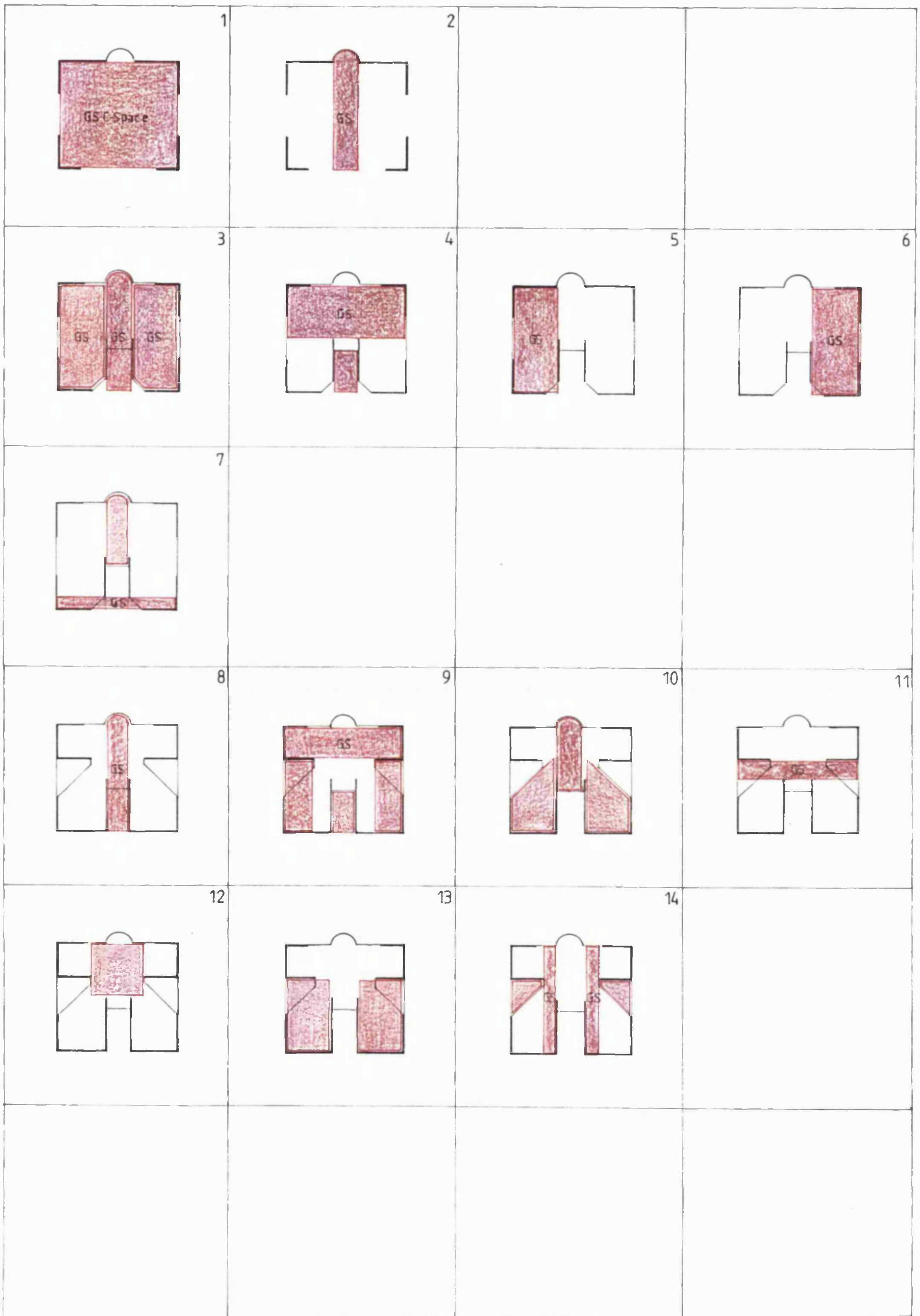


Table **BH2 5.1** - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

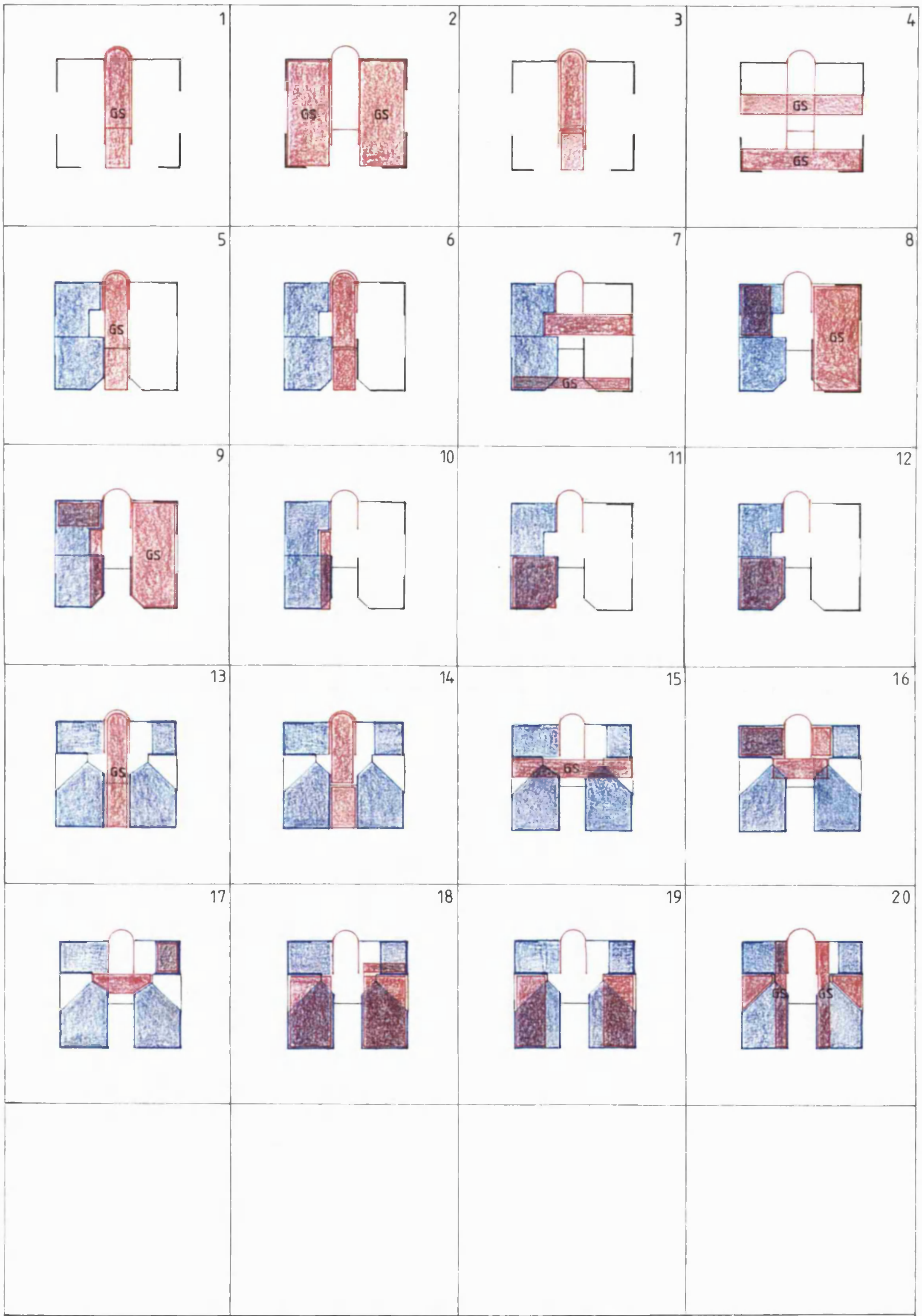


Table BH2 5.2 - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES

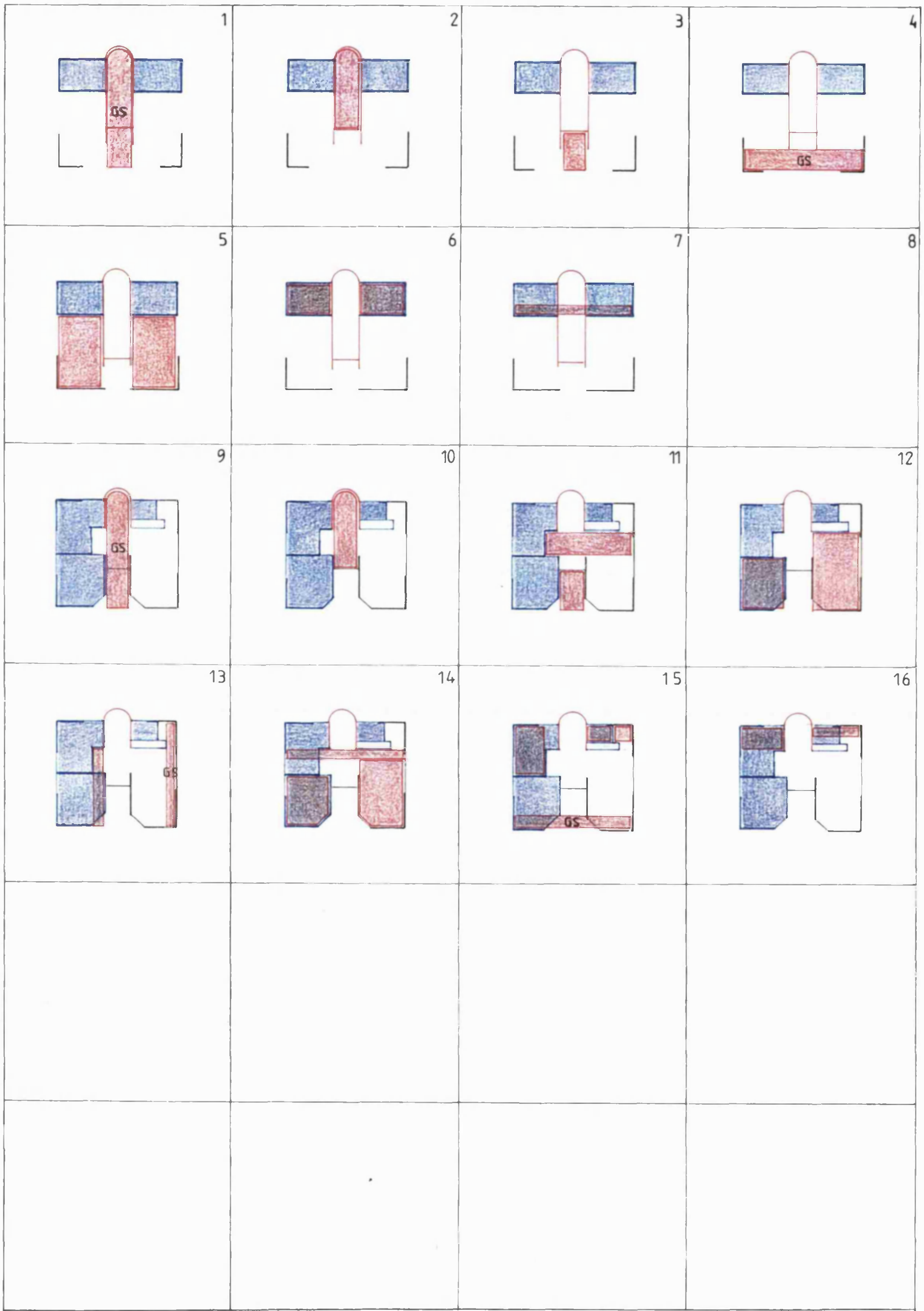


Table **BH2 5.3** - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

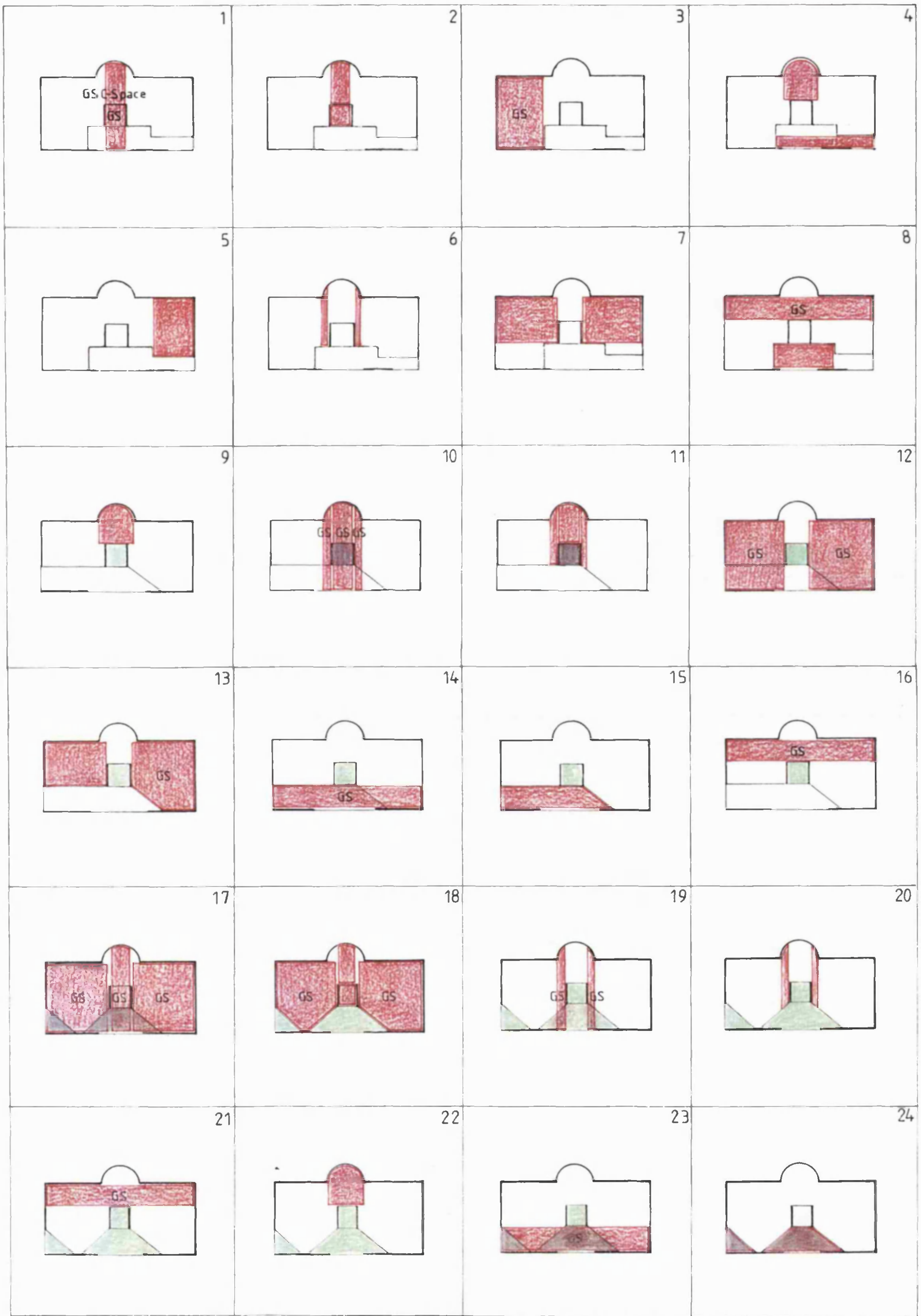


Table **BH3 5.1** - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

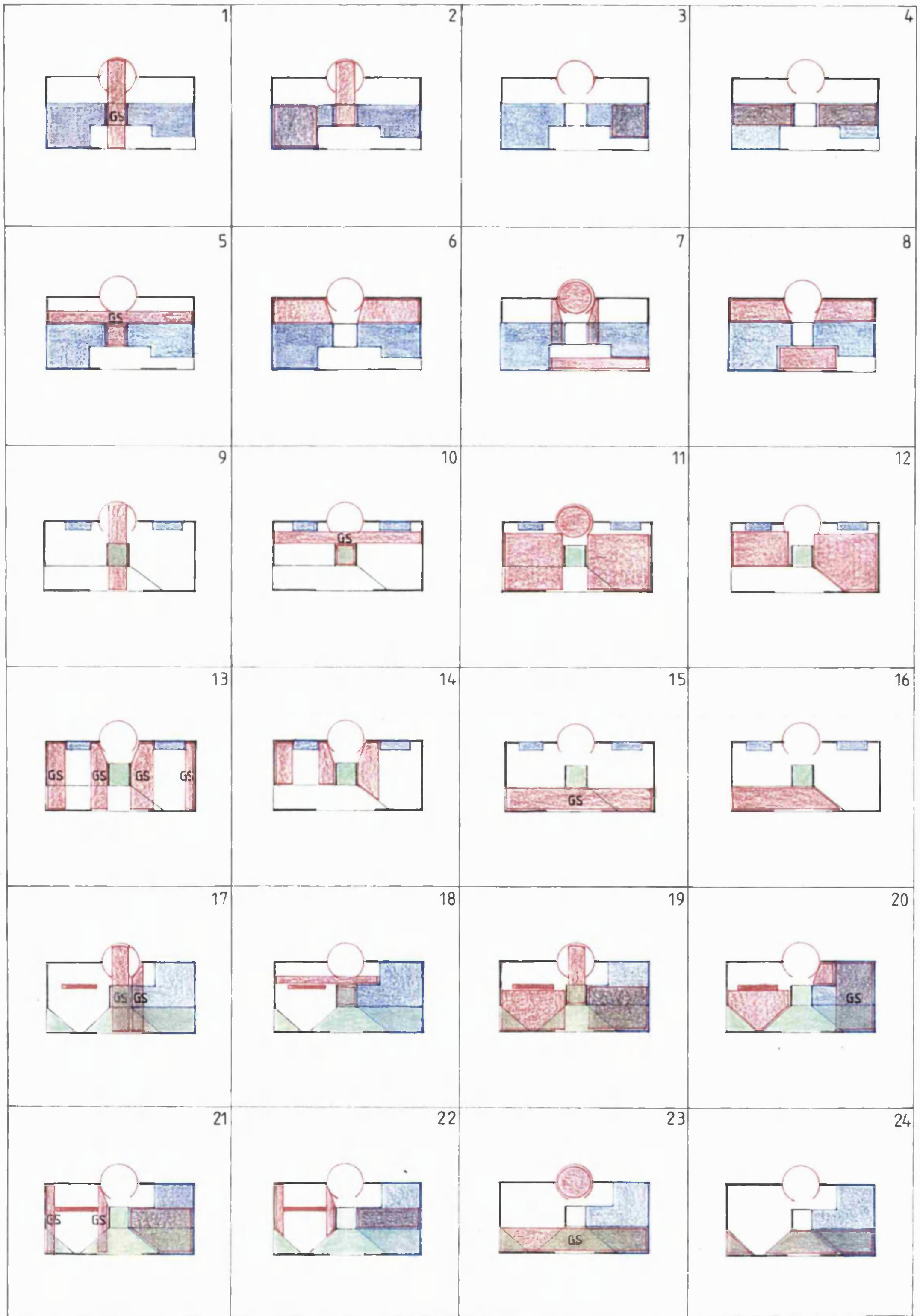


Table **BH3 5.2** - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES


Table BH4 5.3 - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

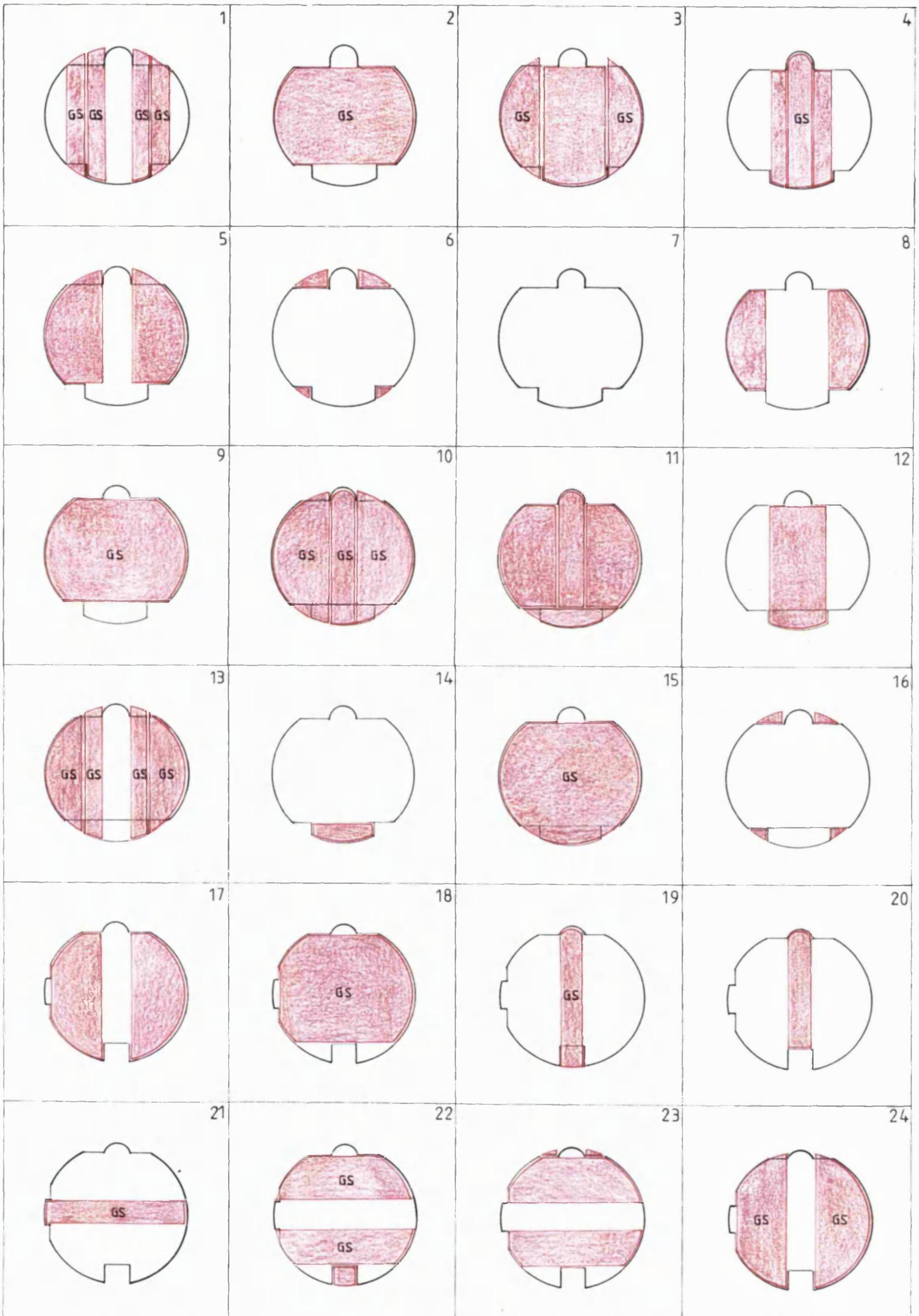


Table **BH4 5.1** - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

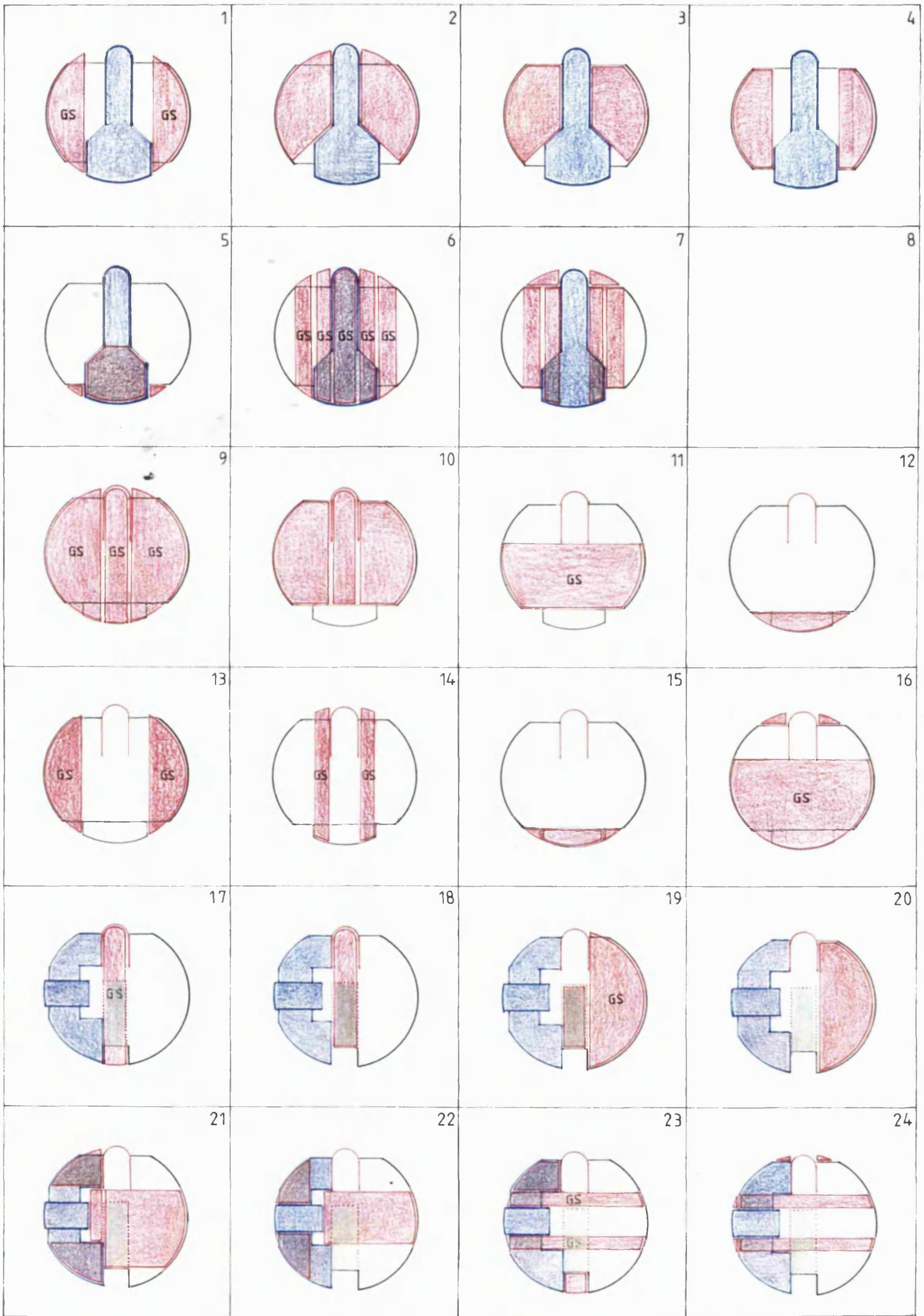


Table BH4 5.2 - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES

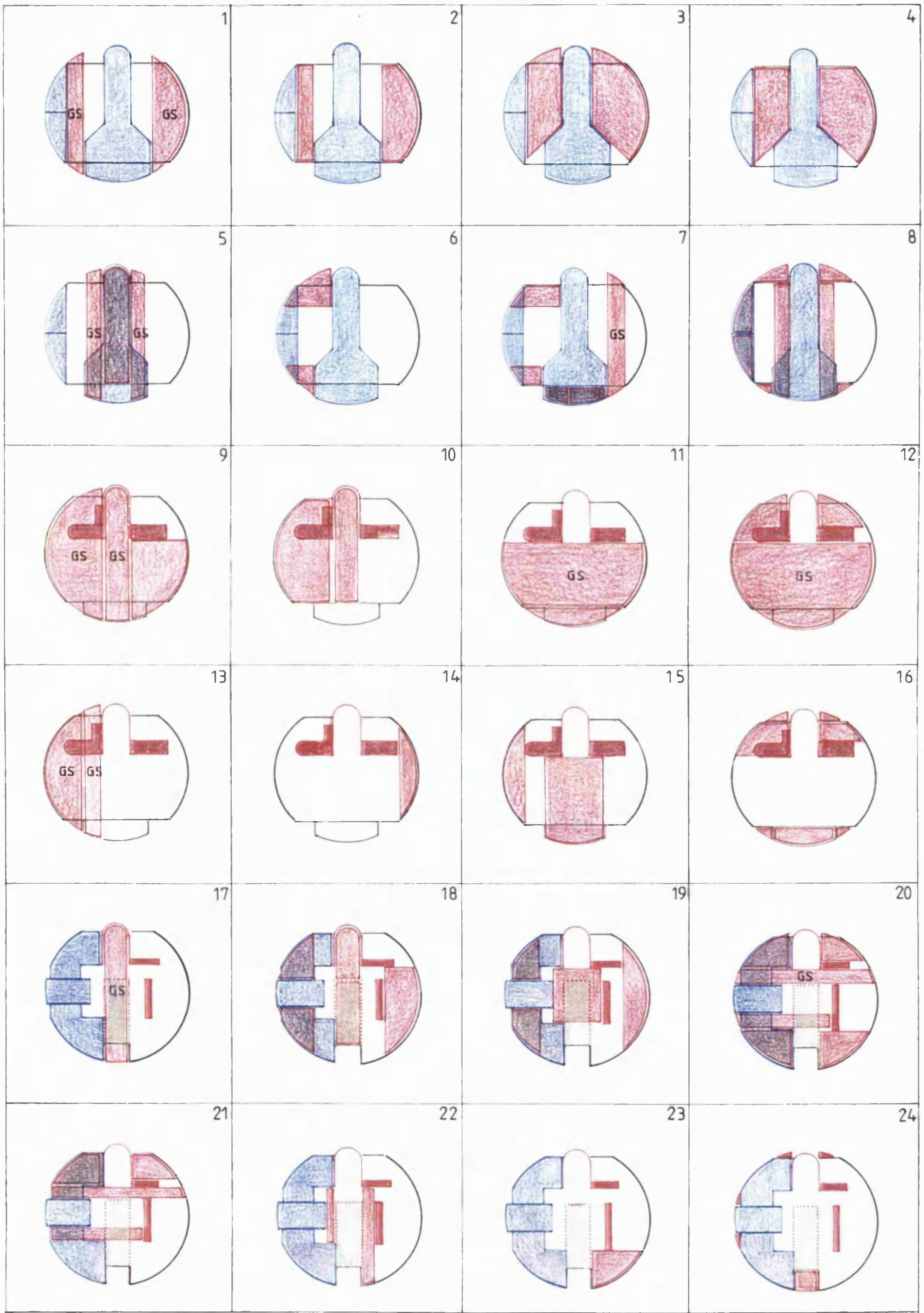


Table BH3 5.3 - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

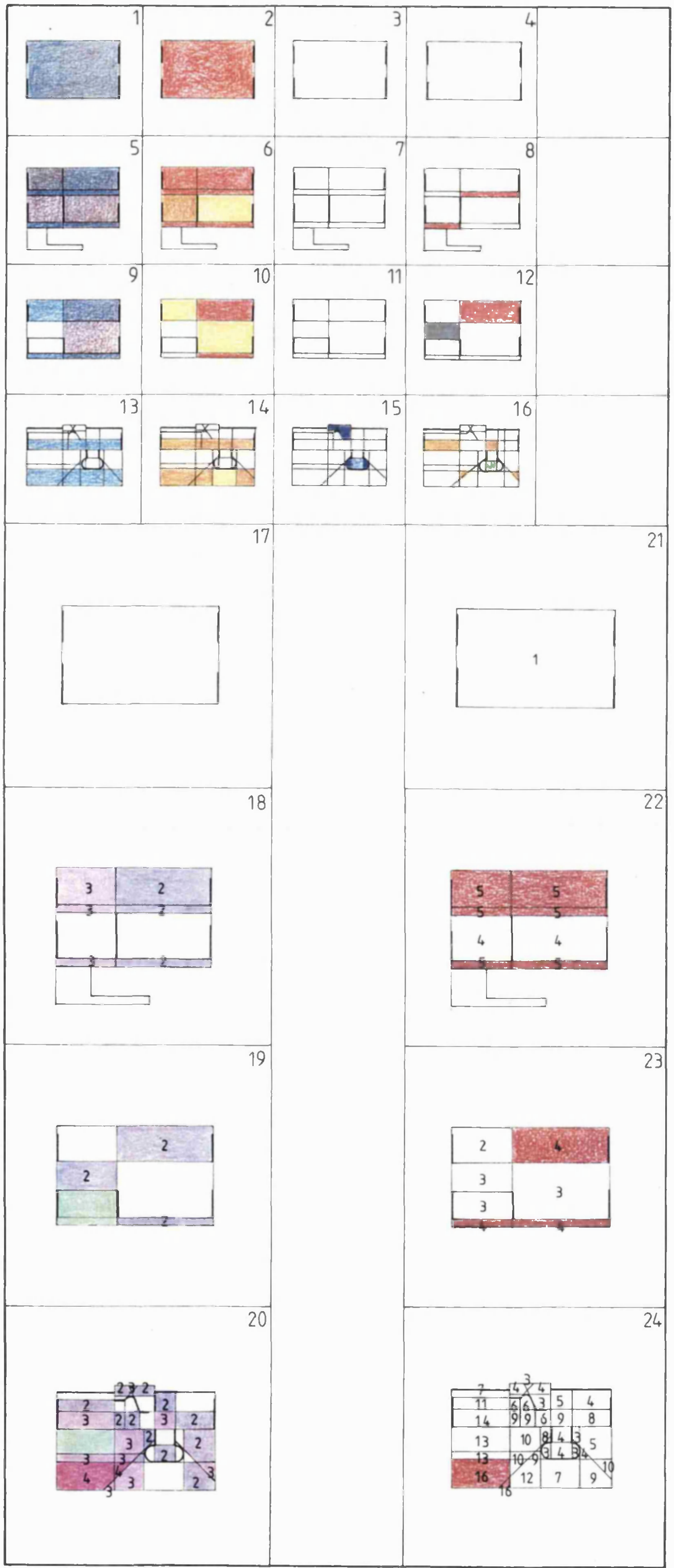


Table **LH1 5.1**

- **L E C O R B U S I E R - V I L L A S T E I N ( L H 1 )**

- **DESCRIPTION OF STAGES**

- **STAGE ONE, (TLH1 5.1)**

The ground floor at stage one is covered by a single Global Scale convex space as a whole, (TLH1 5.1, fig. 1, p. 365). At the first floor there are two Global Scale convex spaces extending at width, as well as a wider and two narrow ones extending at length, (TLH1 5.1, fig. 5, p. 365). At the second floor there is a single Global Scale convex space extending at width. At length there is a Global Scale convex space at the back and a narrow one at the front of the plan, (TLH1 5.1, fig. 9, p. 365). Finally, at the third floor there are two Global Scale convex spaces extending at length, (TLH1 5.1, fig. 13, p. 365).

The overlap units at the first floor cover the left, the back and the front side of the plan, (TLH1 5.1 fig. 18, p. 365). At the second floor there is one overlap unit situated at the back and another one at the front of the plan. There is also an overlap unit situated at the outside space, (TLH1 5.1 fig. 19). Finally, at the third floor there are four clusters of overlap units each of which extends from one corner to the centre of the composition, (TLH1 5.1 fig. 20, p. 365).

Every overlap unit at first floor is a Global Scale unit, (TLH1 5.1 fig. 6, p. 365). At the second and third floor the Global Scale-Unit index is: 0.57 and 0.38 respectively, (TL 5.6, p. 352).

The short path map at the first floor consists of two narrow units each of which stretches from the left or the right side to the centre of the plan, (TLH1 5.1, fig. 8, p. 365). At the second floor there is one short path unit situated at the back right side and another one situated at the terrace, (TLH1 5.1, fig. 12, p. 365). Finally, at the third floor the short path units are scattered in different locations occupying the back left side of the plan, the elliptical volume and the outside space around this volume, (TLH1 5.1 fig. 16, p. 365).

The most connected units at the first floor are the four units at the back and the two units at the front side of the plan, (TLH1 5.1, fig. 22, p. 365). At the second floor these are the narrow units at the front and the unit at the back left side of the plan, (TLH1 5.1 fig. 23, p. 365). Finally, at the third floor the most connected units are the trapezoidal and the triangular unit at the left front side of the plan, (TLH1 5.1, fig. 24, p. 365).

The Invariance-Value index of the most connected units at the first floor is 0.62, (TLH1 5.8, p. 372). At the second and third floor this index is 0.57 and 0.44 respectively. Therefore, there is a large number of

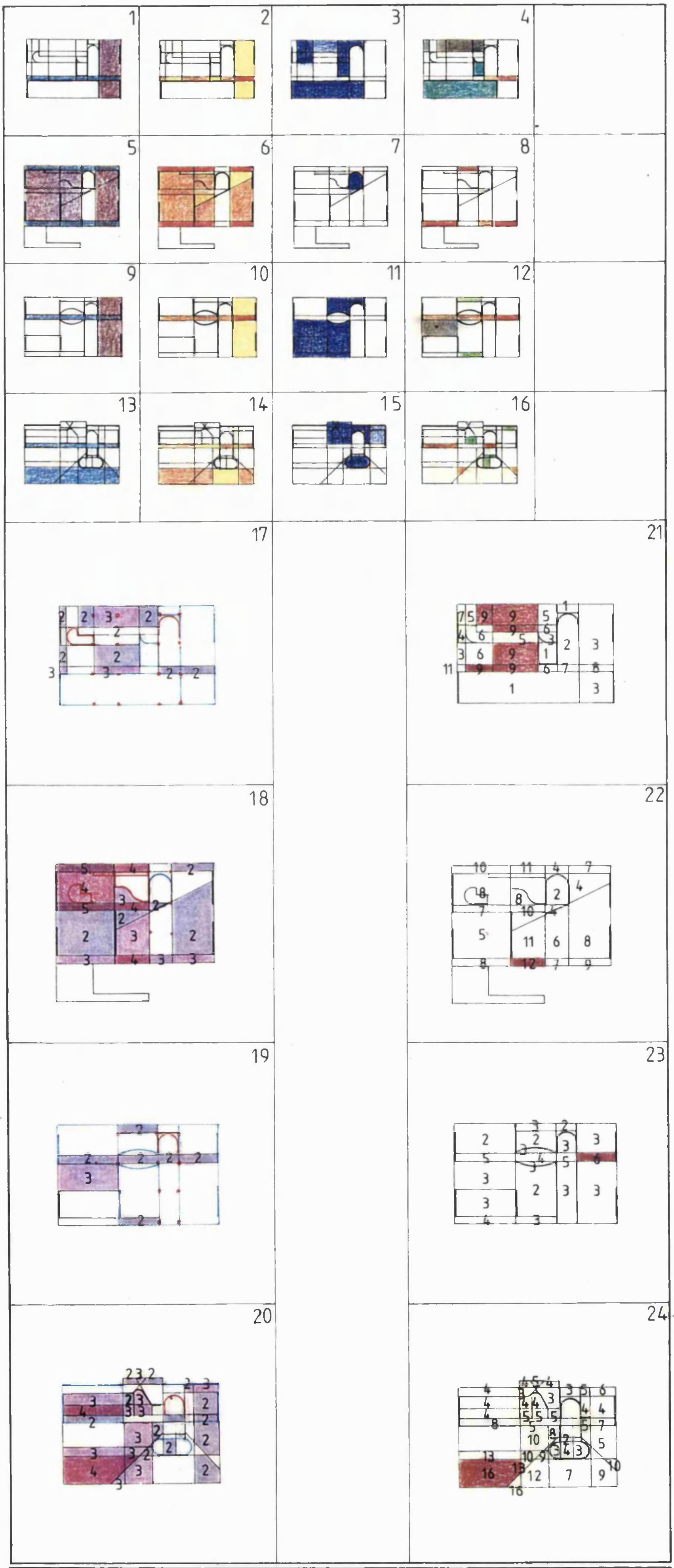


**Table LH1 5.2**

spatial units that are 'seen' from the most connected units in all floors. There is also a large number of spatial units from which the most connected units are constantly 'seen'.

There is no symmetrical disposition of the Global Scale convex spaces, the Global Scale units, the spatial units, the short path units[52], the most connected units and the invariance values in any of these floors, (TLH1 5.1, fig. 1-16, p. 365).

- **STAGE TWO, (TLH1 5.2)**

The transformations occurring at this stage have been identified by Plan analysis as follows: The ground floor is transformed by the superimposition of five elements, most of which are situated next to the periphery of the plan, and the addition of two staircases, (see fig. 2 in TLH1 4.1 of Plan Analysis, p. 281). At the first floor a shape enclosing a staircase is superimposed at the central right side of the layout, (see fig. 5 in TLH1 4.1 of Plan Analysis, p. 281). Further, a second staircase and a piano shaped opening are added at the left side. At the second floor a superimposition of five shapes and the addition of a staircase takes place, (see fig. 8 in TLH1 4.1 of Plan Analysis, p. 281). Finally, at the third floor three elements are superimposed and a staircase is added on the plan, (see fig. 11 in TLH1 4.1 of Plan Analysis, p. 281).

Moving to the spatial properties of these floors analysis starts with a description of the Global Scale convex spaces. At the ground and second floor there is a Global Scale convex space extending at width and a narrow one extending at length, (TLH1 5.2, fig. 1, 9). At the first floor there is one Global Scale convex space covering the centre and two other ones each of which covers one side of the plan, (TLH1 5.2, fig. 5). There is also a narrow Global Scale convex space running at length at the back and another one at the front of the composition. At the third floor the arrangement of these spaces remains as defined at stage one apart from a reduction in the width of the space at the back, (TLH1 5.2 fig. 13).

The overlap units at the ground floor occupy the left back and the left central side of the plan, (TLH1 5.2, fig. 17). They belong to separate clusters so that only the ones belonging to the same cluster share their defining sides. At the first floor these units spread throughout the plan apart from the area around the staircase at the right side of the plan. They are situated next to each other sharing neighbouring sides, (TLH1 5.2, fig. 18). At the second floor there is mainly a linear sequence of narrow overlap units stretching from left to the right side of the plan, (TLH1 5.2, fig. 19). Finally, at the second floor there are four cluster of overlap units each of which stretches from one corner to the centre of the plan, (TLH1 5.2, fig. 11).

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52 The only exception seems to be the third floor plan in which the group of units situated inside and around the elliptical volume are symmetrical with respect to the axis covering the geometrical centre of this element, (TLH1 5.1, fig. 16, p. 365).

The Global Scale unit index at the ground floor is 0.29, (TLH1 5.6, p. 372). At the first, second and third floor this index is: 0.71, 0.31 and 0.26 respectively. Therefore, a large number of fields extending throughout the plan in one or in two directions is offered only at the first floor.

This can be also demonstrated by looking at fig. 3, 11 and 15, (p. 367). As these figures show a large part of the ground, second and third floor are covered by convex spaces that do not overlap with a Global Scale convex space. Therefore, there are many locations in these plans from which only local scale information is available.

The short path units at the ground floor are situated at the back, the front and the centre of the layout, (TLH1 5.2, fig. 4, p. 367). At the first floor there are five short path units that are mainly separated from each other occupying separate locations (TLH1 5.2, fig. 8, p. 367). At the second floor there is a linear sequence of short path units stretching from the left to the right side. There are also two individual units each of which is situated at the back or at the front of the plan, (TLH1 5.2, fig. 12, p. 367). At the third floor the short path units are also scattered in different locations, (TLH1 5.2, fig. 16, p. 367). Therefore, to build a complete picture of these layouts as wholes one has to move extensively from back to front and from one side to the other.

At the ground floor there are two groups of most connected units consisting of three units each. These are situated at the back and the centre of the plan, (TLH1 5.2, fig. 21, p. 367). At the first floor the most connected unit is placed at the central front side of the layout, (TLH1 5.2, fig. 22, p. 367). At the second floor it is found at the right side of the plan, (TLH1 5.2, fig. 23, p. 267). Finally at the third floor the most connected units remain as defined at stage one, (TLH1 5.2, fig. 24, p. 367 ).

The Invariance-Value index at the ground floor is 0.33, (TLH1 5.8, p. 372). At the first, second and third floor this index is: 0.57, 0.31 and 0.35 respectively. Therefore, it is only at the first floor that a large number of spatial units are synchronised from the most connected units as well as a large number of spatial units retain constant contact with the most connected units.

The arrangement of the Global Scale convex spaces, Global Scale units, spatial units, short path units, the most connected units and the invariance values is not governed by overall, 'just about' or local symmetry in any of these floors[53].

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53 The only exception are the Global Scale convex spaces extending at length at the first floor which are symmetrical on the LR axis of the block, (TLH1 5.2, fig. 5, p. 367). Besides, it is only at this floor and at the second floor that the organisation of the spatial units is characterised by local symmetry (Symmetry Spatial-Unit index: 0.14, 0.36 respectively, TLH1 5.2, fig. 18, 19, p. 367, TLH1 5.7, p. 372). This symmetry is based on overlap units the geometrical centre of which is covered by the BF axis. Finally, it is only at the first floor that the most connected unit is situated on the BF axis, (TLH1 5.2, fig. 24, p. 367).

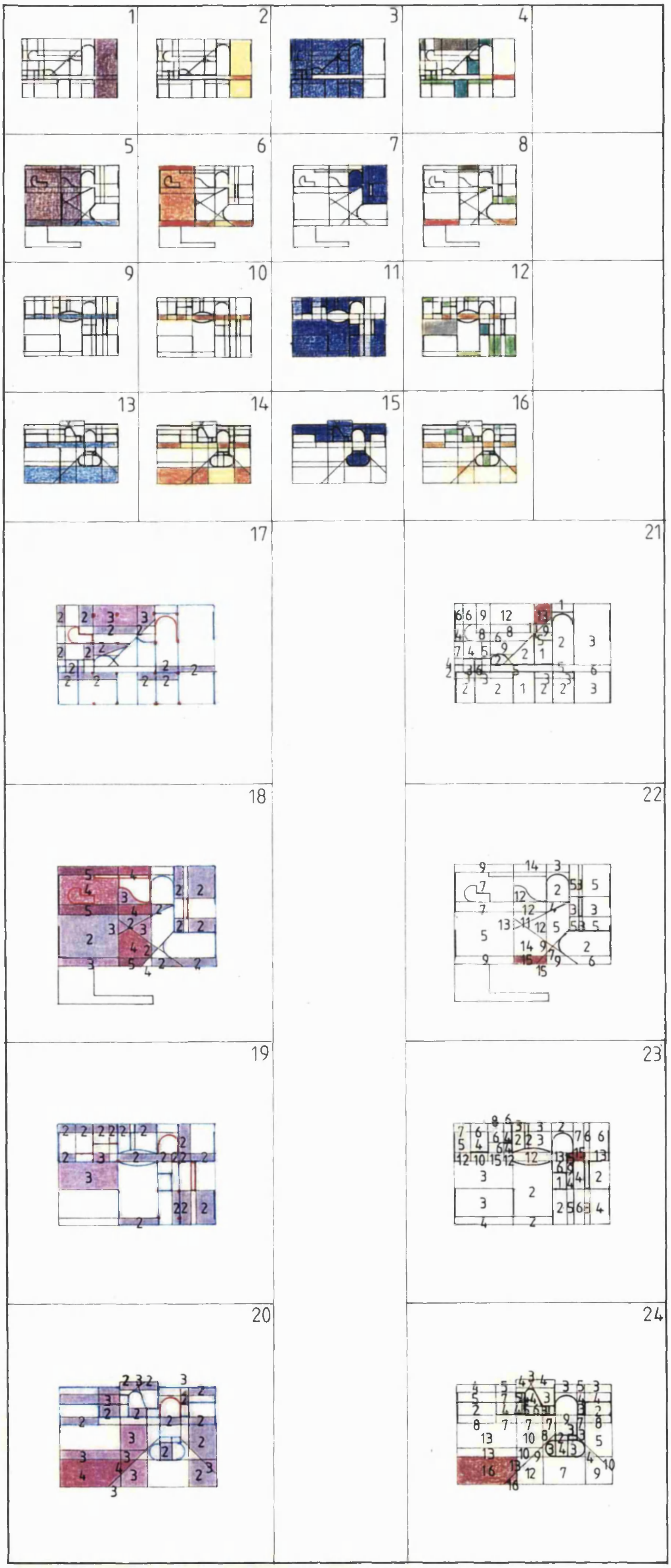

Table **LH1 5.3**

- **STAGE THREE, (TLH1 5.3)**

Stage three results from stage two through changes described in the previous chapter. These are as following: at the ground floor there are five shapes superimposed at the front of the layout and a sixth one at the centre, (see fig. 3 in TLH1 4.1 of Plan Analysis, p. 281). At the ground floor two shapes are superimposed at the right side of the plan, (see fig. 6 in TLH1 4.1 of Plan Analysis, p. 281). At the second floor two shapes are superimposed on the area that is opposite the staircase. Further two interlocking shapes are superimposed at the right side of the plan, while two L-shaped surfaces are added at the left side of it, (see fig. 9 in TLH1 4.1 of Plan Analysis, p. 281). Finally, three shapes are superimposed at the left side of the third floor and two others are superimposed at the right side of this layout, (see fig. 12 in TLH1 4.1 of Plan Analysis, p. 281).

The Global Scale convex spaces travelling at length at the ground floor and at the back of the first floor at stage two are removed, (TLH1 5.3, fig. 1, 5). The one extending at width at the right side of the first and the second floor is also removed, (TLH1 5.3, fig. 5, 9). There are no changes in the Global Scale convex spaces in the third floor, (TLH1 5.3, fig. 13).

At the ground, second and third floor there are very few Global Scale units. This can be also reaffirmed by looking at TLH1 5.6, (p. 352). As this table shows the Global Scale-Unit index at these floors is 0.06, 0.20 and 0.25 respectively. At the first floor this index is 0.50, (TLH1 5.6, p. 372). Therefore, apart from the first floor there are not many visual fields that stretch throughout the plan in one or in two directions.

The overlap units at the ground floor remain as defined at stage one apart from the overlap units introduced inside the enclosed spaces at the front side of the plan, (TLH1 5.3, fig. 17). At the first floor these units cover the left and the central side of the plan sharing their defining sides, (TLH1 5.3, fig. 18). There is also a number of units that are separated from each other. These are situated inside the enclosed spaces at the right side of the composition. At the second and the third floor the overlap units form separate clusters or individual units, (TLH1 5.3, fig. 20).

At this stage there is a large number of convex spaces that do not overlap with a Global Scale convex space, (TLH1 5.3, fig. 3, 11, 15). Therefore, the largest part of the layout provided information that is restricted to the local scale.

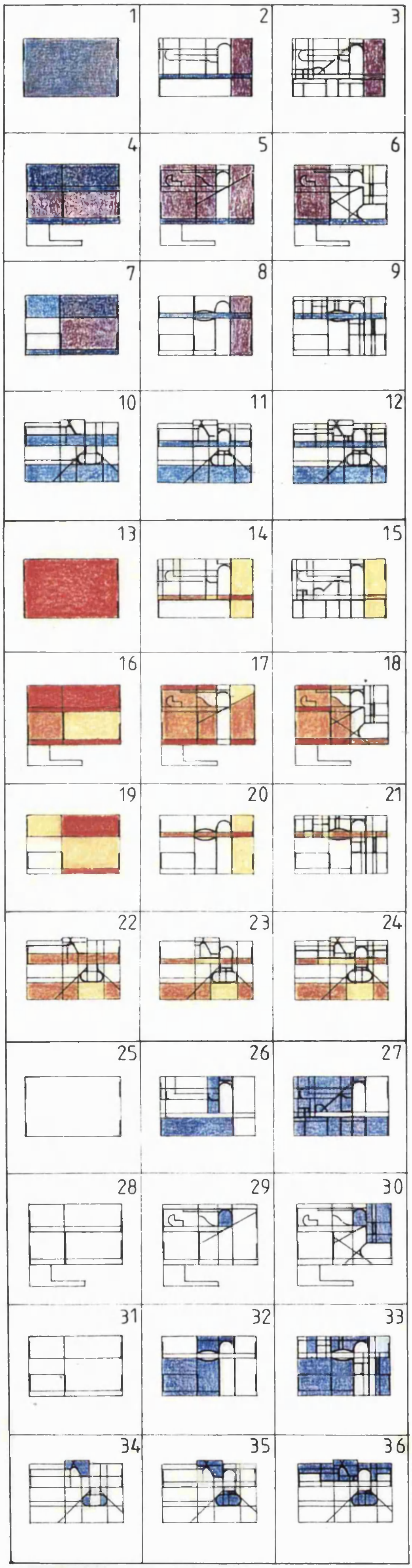


Table **LH1 5.4** - Comparative examination of stages

The short path units at the ground floor spread throughout the plan rarely sharing their defining sides[54], (TLH1 5.3, fig. 4, p. 369). At the rest of the floors these units occupy also separate locations, (TLH1 5.3, fig. 8, 12, 16, p. 369). Therefore, similarly to stage two a total picture of these layouts is provided through large scale movement that stretches throughout the plan.

The most connected unit at the ground floor is found at the left of the staircase situated at the right side of the plan, (TLH1 5.3, fig. 21, p. 369). At the first floor there are two most connected units located at the front of the layout, (TLH1 5.3, fig. 22, p. 369). At the second floor the most connected unit is found at the right side of the plan, (TLH1 5.3, fig. 23, p. 369). Finally, at the third floor the most connected units are situated at the front left corner of the composition, (TLH1 5.3, fig. 24, p. 369).

The Invariance-Value index at the ground floor is 0.28, (TLH1 5.8, p. 372). At the first floor this index is 0.46. Finally, at the second and third floor it is 0.30. Therefore, it is only at the first floor that a considerable degree of synchronisation of spatial units is offered. Besides, it is only at this floor that the most connected units are 'seen' from a relatively large number of spatial units.

Similalry to the previous stages the organisation of the Global Scale convex spaces, the Global Scale units, the spatial units, the short path units, the most connected units and the invariance values does not display overall symmetry, 'just about' symmetry or local symmetry in any floor[55].

- **COMPARISON ACROSS STAGES, (TLH1 5.4)**

- **Spatial properties**

At stage one the whole area of the ground and first floor and a large part of the second floor are covered by Global Scale convex spaces and Global Scale units, (TLH1 5.4, fig. 1, 4, 7, 13, 16, 19). The Global Scale-Unit index at the third floor is 0.38. (TLH1 5.6, p. 372). Therefore, at the first three floors every single location or the majority of spatial locations provides visual fields that extend throughout the plan in one or in two directions. On the other hand, at the third floor there are fewer positions offering global scale information.

The short path units at the first, second and third floor are distanced from each other requiring movement to build a complete picture of these interiors, (TLH1 5.5, fig. 16, 19, 22, p. 371). Besides, they belong

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54 Certain short path units appear as though they share their defining sides. However, these are either overlap units each of which is situated inside an enclosed space or spatial units occupying the whole area of an enclosed space. In this way, they are separated from each other by intervening boundaries.

55 There is local symmetry characterising the disposition of the spatial units at the second floor only, (Symmetry Spatial-Unit index: 0.18, TLH1 5.7, p. 372). This is based on overlap units the geometrical centre of which lies on the BF axis rather than on a symmetrical arrangement of overlap units around this axis.

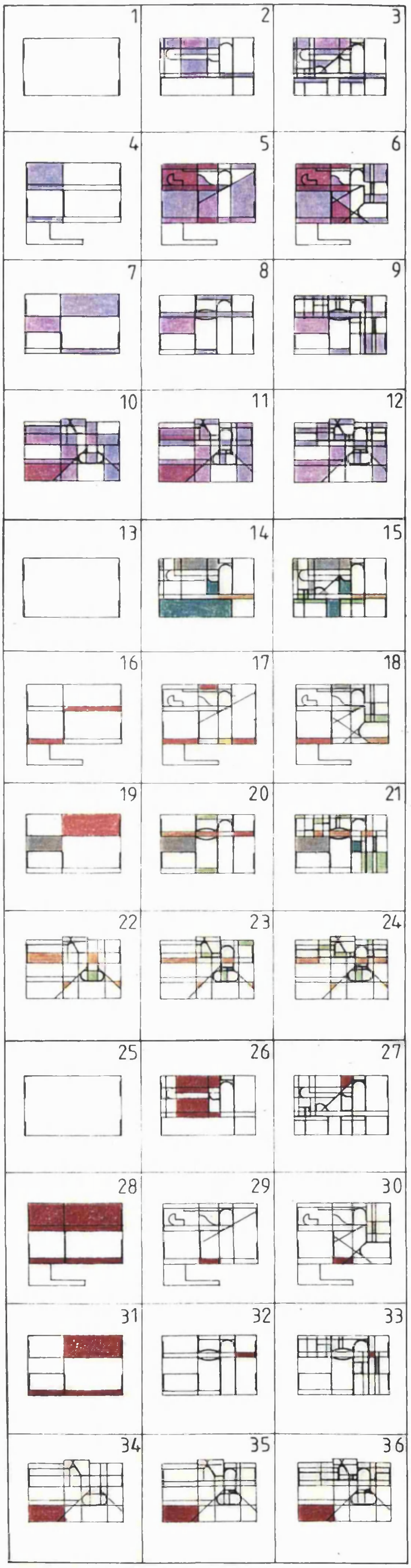


Table **LH1 5.5** - Comparative examination of stages to different convex spaces. Therefore, visual fields produced from these units are different from each other. Thus, although these layouts offer global scale visual information, they look different from different positions.

In the following stages certain Global Scale convex spaces and Global Scale overlap units constructed by their intersections are retained, (TLH1 5.4, fig. 2, 3, 5, 6, 8, 9, 11, 12, 14, 15, 17, 18, 20, 21, 23, 24, 350). Nevertheless, the number of the Global Scale convex spaces at the ground, first and second floor is reduced, (TLH1 5.4, fig. 1-3, 4-6, 7-9, p. 370). Thus, there is a tendency to eliminate global scale information that stays invariant during a sequence of steps.

The Global Scale overlap units constructed by the overlaps amongst the Global Scale convex spaces are consequently reduced also. The Global Scale-Unit index drops from 1 to 0.06 at the ground floor, from 0.57 to 0.20 at the second floor and from 0.38 to 0.25 at the third floor, (TLH1 5.6, p. 372). The decrease of this index shows that spatial transformation reduces not only the provision of global scale information but also the number of visual fields that reach throughout the plan. It is only at the first floor that a large number of such visual fields are constructed, (Global Scale-Unit index 0.50, TLH1 5.6, p. 372).

The restricted provision of global scale information can be also demonstrated by figures 27, 33 and 36, TLH1 5.4, (p. 370). As it was mentioned in the analysis of stage three the coverage of the plans by a large number of convex spaces that do not overlap with Global Scale convex space indicates that from these spaces only local scale information is offered.

From stage two to stage three the clusters of overlap units situated at the outside space at the first and third floor and at the left and back side of the interior at the first floor remain the same, in terms of shape, size and overlap value, (TLH1 5.5, fig. 5, 6, 11, 12). However, there is an increased break up into clusters of smaller overlap units and individual overlap units and an increased separation amongst them by non overlapping units and dividing walls in all floors, (TLH1 5.5, fig. 2, 3, 5, 6, 8, 9, 11, 12). There is also a decrease in the area that is covered by overlap units. The changes in the shape, the size and the distribution of overlap units changes the patterns of relations amongst convex spaces. These changes result in visual information that in most of the cases is reduced to the scale of a single convex space.

Certain short path units are retained throughout the stages, (TLH1 5.5, fig. 13-24). Nevertheless, there is an increased number of short path units and an increased separation of them by intervening boundaries. Therefore, parts of the route leading to a complete picture of the layouts are retained while others change.

Besides, there is no specific pattern of distribution of these units which spread in random arrangements from the back to the front and from the left to the right side of the plan in all floors. Thus, there is no tendency to preserve a specific configuration of the short path that is repeated in every floor. Each floor is

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.29 | 0.06 |
| 1ST | 1 | 0.71 | 0.50 |
| 2ND | 0.57 | 0.31 | 0.20 |
| 3RD | 0.38 | 0.26 | 0.25 |

Table **LH1 5.6**
**GLOBAL SCALE - UNIT INDEX**
(No of Global Scale Spatial Units/Total no of Spatial Units, Excluding units situated in the voids)

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0 | 0 |
| 1ST | 0 | 0.14 | 0.09 |
| 2ND | 0 | 0.36 | 0.18 |
| 3RD | 0 | 0.08 | 0.03 |

Table **LH1 5.7**
SYMMETRY SPATIAL - UNIT INDEX, (BF)
(No of symmetrical Spatial Units/Total no of Spatial Units)

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.33 | 0.28 |
| 1ST | 0.62 | 0.57 | 0.46 |
| 2ND | 0.57 | 0.31 | 0.30 |
| 3RD | 0.44 | 0.35 | 0.30 |

Table **LH1 5.8**
INVARIANCE-VALUE INDEX
(No of spatial units visible from the most connected units / Total no of spatial units)

seen through a random and extensive route that is always different from the routes in the rest of the floors.

Finally, there is no specific pattern of preservation of the shape, size and position of the most connected units[56], (TLH1 5.5, fig. 25-33, p. 371). The Invariance-Value index of these units at the ground floor moves from 1 to 0.28. At the first floor it moves from 0.62 to 0.46. At the second floor it drops from 0.57 to 0.30. Finally, at the third floor it moves from 0.44 to 0.30, (TLH1 5.8, p. 372). Therefore, apart from the first floor the degree of synchronisation of spatial units from the most connected units and the number of visual fields that are constantly connected with these units are reduced.

To summarise, the comparison of stages shows that spatial transformation is based on a preservative and an obliterative mode retaining certain spatial patterns while changing others. However, the obliterative mode seems more prevalent reducing global scale information from one stage to the other. It also reduces the synchronisation of convex spaces and separates the positions from which this is offered. This mode also increases the length of the exploration path and separates its components by intervening walls. Finally, it reduces visual synchronisation achieved by the most connected units and the number of visual fields that retain constant contact with these units.

- **Physical properties of spatial articulation**

At stage one all surfaces of the block at the ground and first floor as well as the right, the back and the front surfaces at the second floor are visible from the Global Scale convex spaces extending next to them, (TLH1 5.4, fig. 1, 4, 7, p. 370). At the third floor the front surface of the interior can be also observed in full length, (TLH1 5.4 fig. 10, p. 370). Besides, the large coverage of all floors by Global Scale units shows that visual fields constantly synchronise opposite outer surfaces, (TLH1 5.4, fig. 13, 16, 19, 22, p. 370). However, according to the short path map there is no simultaneous access to these surfaces from a single location, (TLH1 5.5, fig. 16, 19, 22, p. 371).

At stages two and three the numbers of visual fields that offer constant access to the full length of the outer surfaces are eliminated following the elimination of Global Scale convex spaces, (TLH1 5.4, fig. 2, 3, 5, 6, 8, 9, p. 370). Most of these surfaces are made discontinuous so that only fragments of them are visible from different positions[57]. Besides, there is a small number of visual fields that synchronise parts of the outer surfaces from distance based on a decrease of the Global Scale unit index, (TLH1 5.4. fig. 14, 15, 17, 18, 20, 21, 23, 24, p. 370).

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56 It is only at the third floor that these units are retained in terms of these parameters, (TLH1 5.5, fig. 34-36, p. 371).

57 At stage three it is only the right surface of the block at the ground floor and the left and front surface at the first floor that can be seen in their entirety through the Global Scale convex spaces extending at these positions, (TLH1 5.4, fig. 3, 6, p. 370).

The large and continuous coverage of the first floor by overlap units shows that the physical elements become successively synchronised. Some of these units are Global Scale units, (TLH1 5.4, fig. 18, TLH1 5.5, fig. 6, p. 370). Therefore, visual fields in this floors successively synchronise global and local scale physical relations. In the rest of the floors the area the overlap units occupy is reduced, (TLH1 6.5, fig. 3, 9, 12, p. 371). This reduction together with their separation by non overlap units and intervening boundaries shows that visual fields often integrate the defining surfaces of a single convex space.

Therefore, the comparative examination of stages shows that the elimination of spatial properties results in an elimination of physical properties. At the first floor peripheral global scale exploration reveals the front and left outer surfaces in full length. Besides, a step by step small scale exploration gradually synchronises the outer and the inner surfaces. In the rest of the floors the outer and the inner surfaces are experienced as discontinuous and separated from each other elements.

- **Geometrical properties of spatial articulation**

Analysis of each stage showed that there is no overall symmetry, 'just about' symmetry or local symmetry characterising the organisation of any of the spatial systems in any floor. The only exceptions are the spatial units at the first and second floor which exhibit local patterns of symmetry on the BF axis[58], (TLH1 5.5, fig. 8, 9, TLH1 6.7, p. 371).

The lack of symmetry in the organisation of spatial properties shows that there is no geometrical co-ordination of visual information. Therefore, the patterns of global and local scale information transmission have no underlying geometrical order that relates adjacent and separate spaces together.

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58 However, it is only the placement of the geometrical centres of certain units on the BF axis that generates this symmetry rather than a symmetrical distribution of elements on the left and right side of this axis. The asymmetrical organisation of the rest of the systems makes the placement of these units on the BF axis difficult to grasp. Besides, enclosing boundaries separate these units form each other and from the rest of the plan, (TLH1 5.5, fig. 8, 9, p. 371). Thus, a viewer stepping inside these rooms cannot grasp their placement on the BF axis.

At the first floor the units located on this axis are situated on the same Global Scale convex space running at width of the composition, (TLH1 5.5, fig. 5, 6, p. 371). In this case one can see these units simultaneously and understand their relations better. However, it is only from the units located next to the front surface that one can perceive that he occupies a geometrically significant location. This is because he can also see the GS c-space extending at length and understand the position of these units in the context of the volume as a whole.

## • COMPARISON ACROSS LE CORBUSIER'S HOUSES

This section looks at all houses of Le Corbusier together. The aim is to identify the similarities and differences amongst them that can lead to the answer of the question set at the beginning of this chapter, i.e. how these houses become intelligible during spatial experience?

This section also examines the design logic that governs the transformation of spatial articulation. Therefore, it raises the following questions also :

- Is there a consistent pattern of transformation?
- Which are the rules characterising this transformation? i.e. which are the properties that stay invariant along this transformation?

To answer to first question the degree to which stages are specific to particular elements and their distributions is examined. The purpose is to identify specific design strategies in the transformation of the layouts based on associations between higher and lower levels of articulation with configurational patterns. The second question is clarified by looking at the degree to which the properties of the first stage are preserved throughout the stages.

Seven tables of figures are used in this section each of which represents the transformation of Global Scale convex spaces, Global Scale units and so on in all four houses, (TL 5.1-TL 5.7, p.p. 378-381, 385). There are also three tables of analytic measurements accounting for the transformation of various indexes, (TL 5.8-TL 5.10, p.p. 378, 390).

## • THE PATTERNS OF THE TRANSFORMATION PROCESS

### • Global Scale convex spaces, (TL 5.1)

The examination of the patterns of distribution of the Global Scale convex spaces in each stage will show that there is a specific logic that associates certain stages with certain configurations of these spaces and certain positions they occupy on the plans.

At stage one there is one Global Scale convex space extending at width at the left side and one at the right side of the layout in five plans, (5/12), (TL 5.1, fig. 4, 13, 19, 28, 34, p. 378). There is also one Global Scale convex space situated either at the left or at the right side in three plans[59], (3/12), (TL 5.1, fig. 7,

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59 The rest of the plans have either one Global Scale convex space that is not attached to any side, (1/12), (TL 5.1, fig. 16, p. 378), or a single Global Scale convex space covering the layout as a whole, (2/12), (TL 5.1, fig. 1, 31, p. 378), or no Global Scale convex space extending at width, (2/12), (TL 5.1 fig. 10, 25, p. 378).

16, 22, p. 378). Further, two plans are covered as wholes by a single Global Scale convex space, (TL 5.1, fig. 1, 31, p. 378).

The configuration of the Global Scale convex spaces at length is as following: both the back and the front sides of the layout are covered by Global Scale convex spaces in four plans, (4/12), (TL 5.1, fig. 4, 7, 19, 25, p. 378). There is a Global Scale convex space either at the back or at the front side in four plans, (4/12), (TL 5.1, fig. 10, 13, 16, 22, p. 378). Finally, there is one Global Scale convex space not attached to any side in five plans, (5/12), (TL 5.1, fig. 4, 10, 22, 28, 34, p. 378).

At stage two there is one Global Scale convex space extending at width in each side of the layout in three out of twelve plans, (3/12), (TL 5.1, fig. 5, 14, 20, p. 378). There is one Global Scale convex space extending next to a single side in six plans, (6/12), (TL 5.1, fig. 2, 8, 17, 23, 29, 35, p. 378). There is one or two Global Scale convex spaces that are not attached to any side in three plans, (3/12), (TL 5.1, fig. 17, 23, 32, p. 378). Finally, there is no Global Scale convex space at width in two plans, (2/12), (TL 5.1, fig. 11, 26, p. 378).

At length there is one Global Scale convex space at the back and one at the front side of the layout in two plans, (2/12), (TL 5.1, fig. 5, 26, p. 378). There is also one or two Global Scale convex space at the front of the layout in four plans, (4/12), (TL 5.1, fig. 14, 17, 20, 32, p. 378). There is one Global Scale convex spaces not attached to any side in five plans, (5/12), (TL 5.1, fig. 2, 8, 11, 29, 35, p. 378).

At stage three there is one Global Scale convex space extending at width on either side of the composition in two plans, (2/12), (TL 5.1, fig. 15, 21, p. 378). There is also one Global Scale convex space on one side in six plans, (6/12), (TL 5.1, fig. 3, 6, 18, 24, 29, 36, p. 378). There is one Global Scale convex space not attached to any side in two plans, (2/12), (TL 5.1, fig. 18, 33, p. 378). Finally, there is no Global Scale convex space at width in three plans, (3/12), (TL 5.1, fig. 9, 12, 27, p. 378).

At length there is one or more Global Scale convex space either at the back or at the front in six plans, (6/12), (TL 5.1, fig. 6, 12, 15, 21, 27, 33, p. 378). There is one Global Scale convex space not attached to any side in four plans, (4/12), (TL 5.1, fig. 9, 12, 30, 36, p. 378). Finally, there is no Global Scale convex space at length in three plans, (3/12), (TL 5.1, fig. 3, 18, 24, p. 378).

To summarise, stage one is associated with the definition of one Global Scale convex space extending at width on either side of the plan, (5/12 plans). It is also associated with a Global Scale convex space extending at length at the back and one at the front of the layout, (4/12 plans), with a Global Scale convex space either at the back or at the front, (5/12 plans) and a Global Scale convex space that is not attached to any side of the plan, (5/12 plans). Stages two and three are mainly associated with a Global Scale convex space running at width next to the left or the right side, (6/12 plans). It is also associated with a Global Scale convex space running at the front of the layout, (6/12 plans).

As it was suggested at the beginning of this inquiry there is a consistency in the transformation of these layouts which connects certain configurational patterns of the Global Scale convex spaces with certain positions on the plans. However, the Global Scale convex space extending at length occupies either the left or the right side of the plan. Thus, there is a consistency specifying a position next to an outer surface but no consistency regarding which this position exactly is.

- **The Global Scale units, (TL 5.2)**

As it was explained above the Global Scale units arise from the overlaps amongst Global Scale convex spaces as well as amongst these spaces and Local scale convex spaces. Thus, the transformation patterns of the Global Scale convex spaces affect the transformation pattern of the Global Scale units. This means that the association of the configurational patterns of these spaces with stages carries with it an association of the configurational patterns of Global Scale units with these stages.

Besides, the consistent pattern of distribution of the Global Scale convex spaces on the plans on specific places results in a consistent pattern of distribution of the Global Scale units on these places, (TL 5.2, fig. 1-36, p. 379). Nevertheless, the exact position of some units changes from plan to plan and from house to house following the changes characterising the position of Global Scale convex spaces.

- **Global Scale convex spaces overlapping with Local Scale convex spaces, (TL 5.3)**

At stage one almost every Local Scale convex space overlaps with a Global Scale convex one, (TL 5.3, fig. 1, 4, 7, 19, 22, 25, 28, 31, 34, p. 380), in the majority of the plans. The only exceptions are the third floor of LH1 and the ground and first floor of LH2, (TL 5.3, fig. 10, 13, 16, p. 380). At stages two and three a large number of the layout is covered by units that do not belong to a Global Scale convex space. From stage two to stage three the number of these units increases. Therefore, there is a systematic development that increasingly assigns non overlapping Global and Local Scale convex spaces to stages two and three

- **The overlap units, (TL 5. 4)**

At stage one the overlap units form clusters that are distributed on separate areas on the plans[60], (TL 5.4, fig. 4, 7, 13, 16, 19, 22, 25, 28, p. 381). At stage two there is a reduction of the size of the these units and an increase of their number, (TL 5.4, fig. 2, 5, 8, 14, 17, 20, 23, 26, 29, 32, 35, p. 381). There is also a distribution pattern in which clusters of overlap units and individual overlap units are separated from each other by non overlapping units and boundaries. At stage three these characteristics become more accentuated, (TL 5.4, fig. 3, 6, 9, 12, 15, 18, 21, 24, 30, 33, 36, p. 381). Thus, there is a

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60 The only exception is the first floor of LH2 at stage one in which the o-units cover almost the whole area of the plan situated side by side, (TL 5.4, fig. 16, p. 370).

transformation logic associating certain stages with certain configurational patterns of the overlap units regarding their number, shape, size and distribution.

In each stage there is a large cluster consisting of large overlap units that either extends from the outside to the inside space or is situated on a specific area of the plans. Therefore, there is a specific transformation logic associating certain configurational patterns of the overlap units with certain locations.

However, similalry to the spatial elements examined before the position of this cluster changes from plan to plan and from house to house. This is because the position of the outside space changes from each horizontal level to the other and from each house to the other.

- **The short path units, (TL 5.5)**

At stage one the short path units spread in different locations[61], (TL 5.5, fig. 4, 7, 10, 13, 16, 19, 22, 25, 28, p. 382). At stage two the numbers of these units and their degrees of separations are increased with the introduction of intervening walls, (TL 5.5, fig. 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, p. 382). At stage three there is a further increase in the number and the separation of these units, (TL 5.5, fig. 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, p. 382). Therefore, there is a certain logic that associates certain stages with certain configurational patterns of the short path map.

Besides, certain short path units defined at stage one or at stage two remain the same in the following stages in terms of shape, size and position. Thus, there is an association between certain stages, certain short path units and certain positions. Nevertheless, there is not a specific configuration of the short path units. Thus, their arrangement develops randomly and is different from one floor to the other and from one house to the other.

- **The most connected units, (TL 5.6)**

At stage one the most connected units are located next to the sides or at one corner of the volume in nine plans, (9/12), (TL 5.6, fig. 4, 7, 10, 16, 19, 22, 25, 28, 34, p. 383). At stage two these units occupy similar positions in nine plans also, (9/12), (TL 5.6, fig. 2, 5, 8, 11, 14, 20, 23, 29, 23, p. 383). At stage three the most connected units occupy these positions in seven plans, (7/12), (TL 5.6, fig. 3, 6, 12, 15, 21, 30, 33, p. 383). Besides, from stage two to three the most connected units are preserved in terms of shape, size and position or simply in terms of position in six plans, (6/12), (TL 5.6, fig. 3, 6, 12, 15, 33, 36, p. 383). Thus, there is a specific pattern of distribution of these units throughout the stages in the majority of the plans. There is also a pattern of association between stages, most connected units and their locations.

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61 The only exceptions are third floor of LH4 where short path units are arranged side by side, (TL 5.5, fig. 34, p. 382).

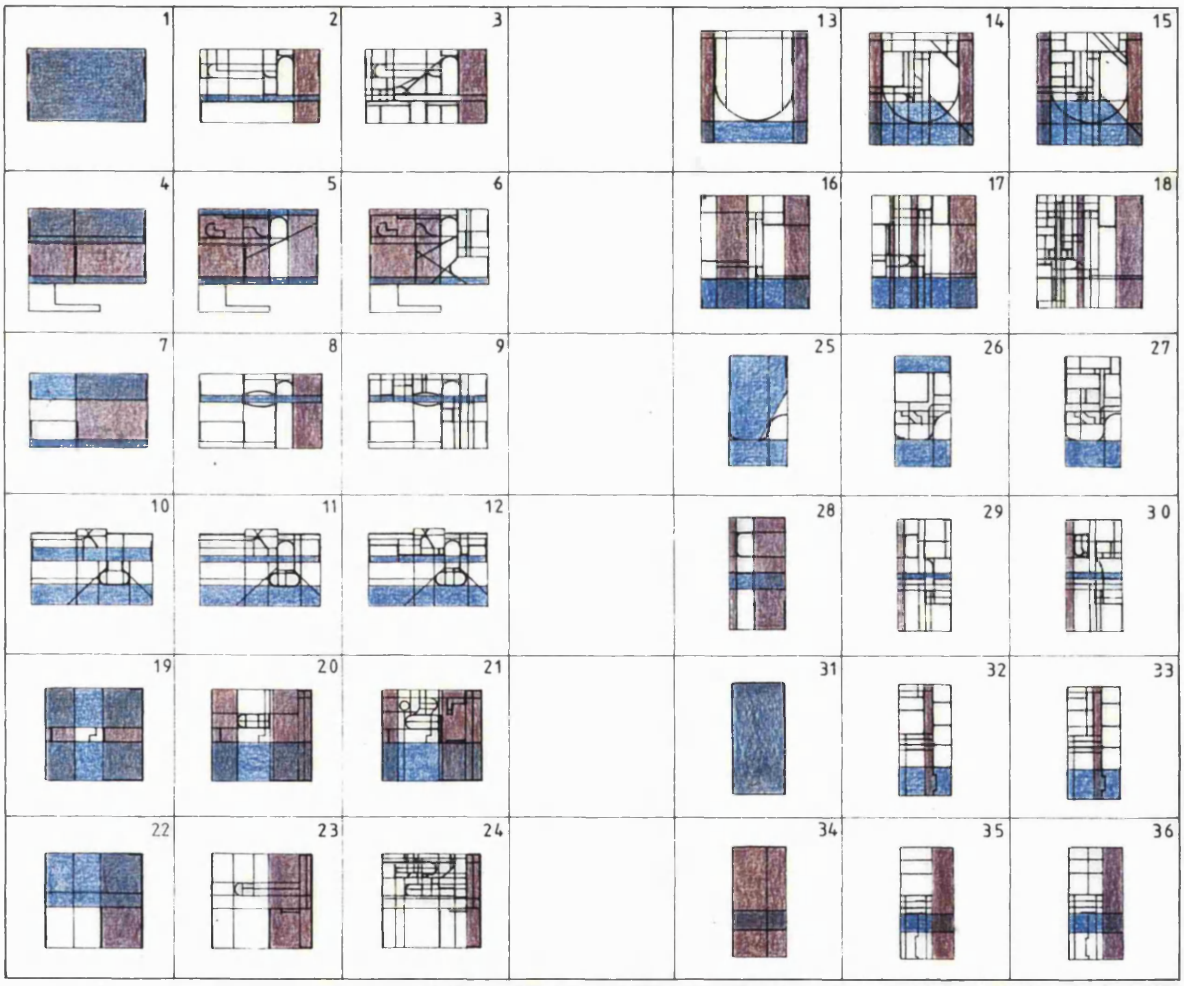


Table L 5.1 - GLOBAL SCALE CONVEX SPACES
Comparative examination of Le Corbusier's houses


**Table L 5.2 - GLOBAL SCALE UNITS**
Comparative examination of Le Corbusier's houses

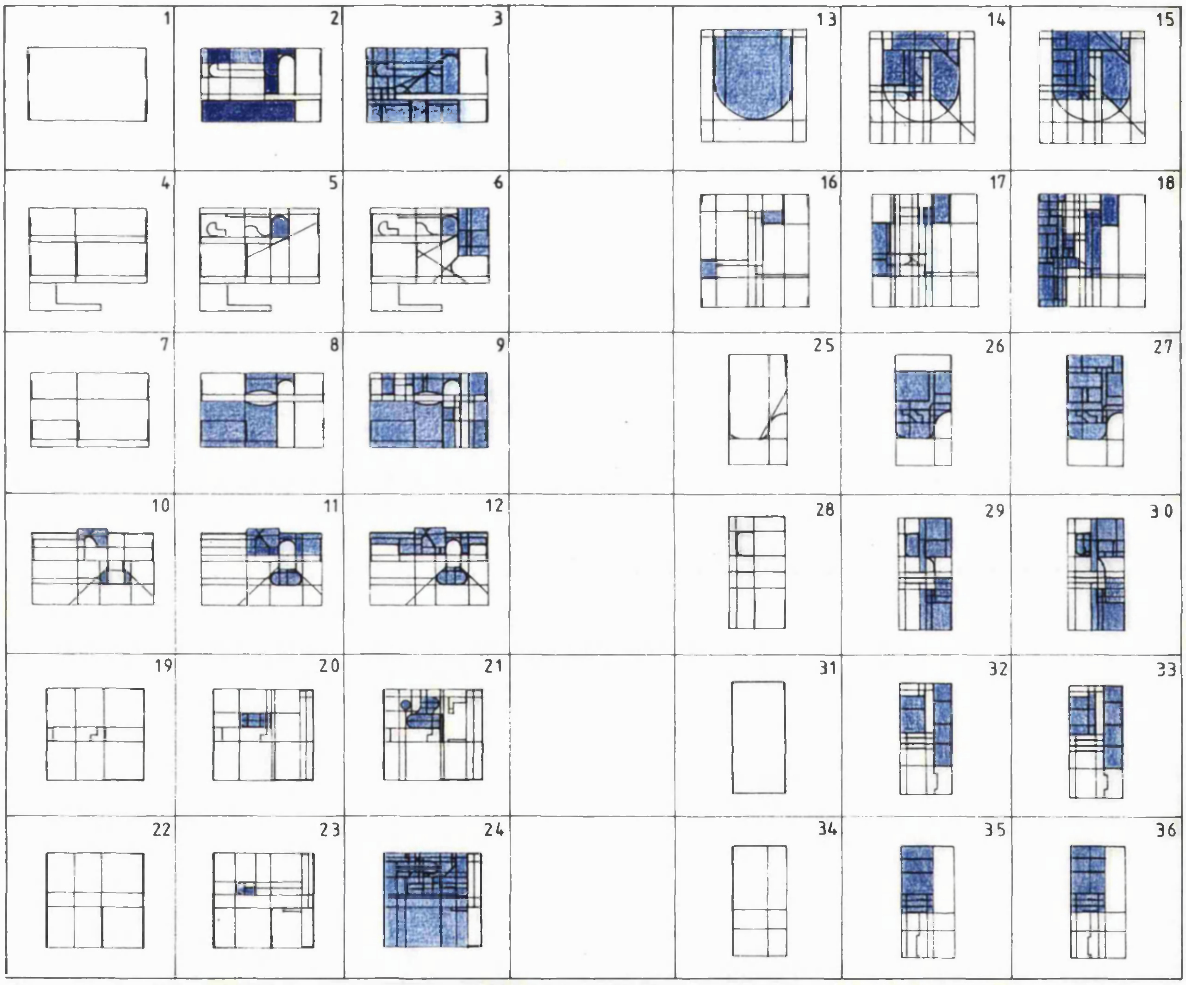


Table L 5.3 - LOCAL SCALE CONVEX SPACES NOT OVERLAPPING WITH GLOBAL SCALE CONVEX SPACES
Comparative examination of Le Corbusier's houses

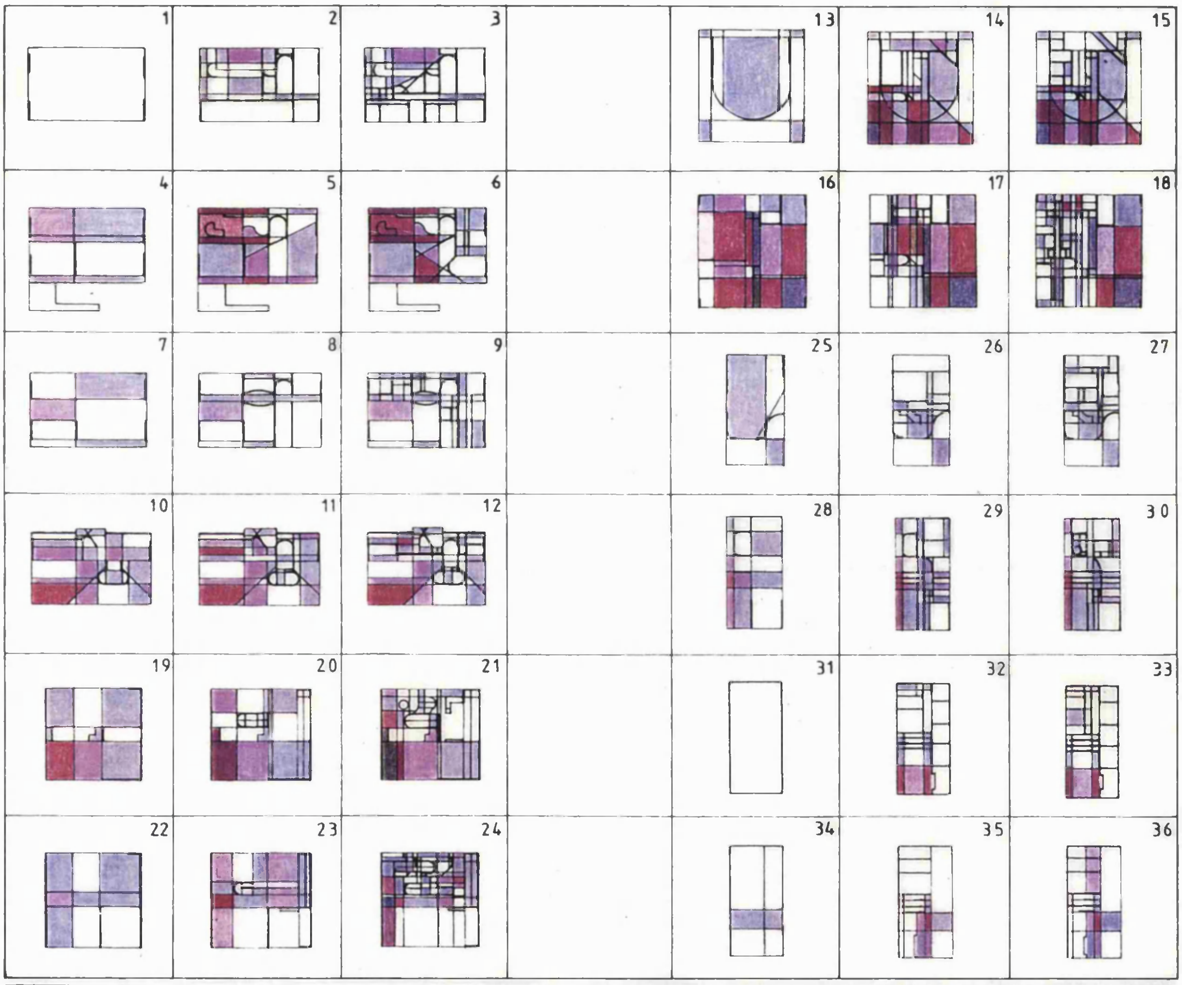


Table L 5.4 - OVERLAP UNITS
Comparative examination of Le Corbusier's houses


Table L 5.5 - SHORT PATH UNITS
Comparative examination of Le Corbusier's houses


Table L 5.6 - MOST CONNECTED UNITS
Comparative examination of Le Corbusier's houses

To summarise, a specific logic governs the configuration of the spatial systems in terms of the distribution of elements and their interrelationships. Besides, there is an association between particular stages, particular configuration patterns and particular positions elements occupy on the plans. *These observations suggest that there is a specific strategy in the ways the architect transforms spatial articulation of his interiors.*

However, analysis showed that the specifications regarding the placement of elements on the plans are general enough allowing variations in terms of the exact positions of these elements. *These variations result in arrangements that in spite of consistencies look different from each other.* The effects these differences have in the ways the houses are experienced will be examined in the following sections.

- **THE PROPERTIES OF THE TRANSFORMATION PROCESS**
- **Spatial properties**

- **STAGE ONE**

At stage one there is a large coverage of the plans by Global Scale convex spaces and Global Scale units, (TL 5.1, TL 5.2, fig. 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, p. 378). Therefore, global scale visual information is transmitted from a large number of locations. This can be reaffirmed by looking at the Global Scale unit index. This is above 0.57 in nine plans[62], (9/12), (TL 5.8, p. 378).

The Invariance-Value index is above 0.42 in ten plans[63], (10/12). Therefore, there is a certain degree of visual synchronisation of spatial relations from a single or from a small number of units. There is also a certain number of visual fields that retain constant contact with these units.

However, the short path units are separated from each other, (TL 5. 5, fig. 4, 7, 10, 13, 16, 19, 22, 25, 28, p. 382). Thus, movement is required to see these layouts as wholes extending from the back to the front and from the left to the right side of the plan[64].

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62 These are the ground, first and second floor of LH1, the ground and first floor of LH3 and the first, second and third floor of LH4.

63 These are all floors of LH1, the first floor of LH2, both floors of LH3 and the first, second and third floor of LH4.

64 The only exception is the third floor of LH4, (TL 5.5, fig. 34, p. 382). In the first two the layout is seen as a whole at once being covered by a single convex space. In the third one the short path units share their defining sides. Standing on the common side one can see the layout as a whole at once. The ground floor of LH1 and the second floor of LH4 are also exceptional cases. This is because they are described by a single convex space that exposes them as wholes at a single glance, (TL 5.5, fig. 1, 31, p. 382).

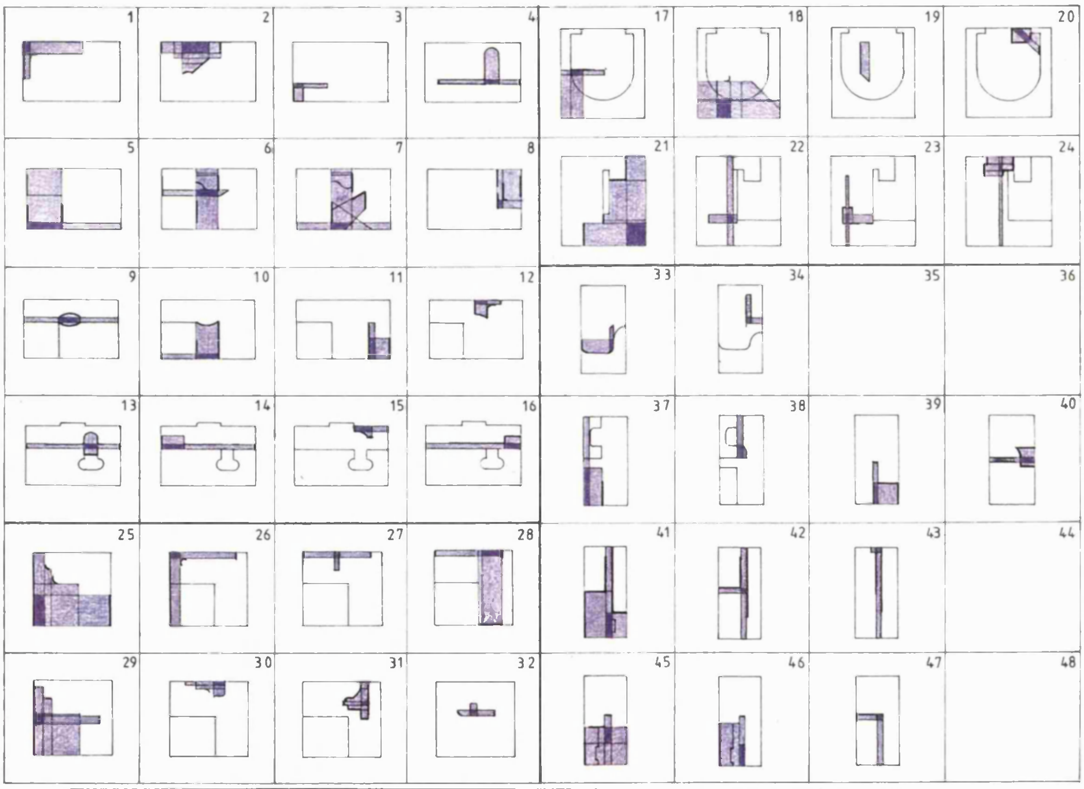


**Table L 5.7 - VISUAL FIELDS**
Comparative examination of Le Corbusier's houses

- **STAGES TWO AND THREE**

From stage one to stage three eight plans retain at least one Global Scale convex space extending at width on one side of the composition, (8/12). (TL 5.1, fig. 3, 6, 15, 18, 21, 24, 30, 36, p. 378). Besides, six plans retain the Global Scale convex space extending at length at the front of the layout, (6/12), (TL 5.1, fig. 6, 12, 15, 21, 27, 33, p. 378). Most of these spaces either extend from the outside to the inside space, (TL 5.1, fig. 6, 15, 18, 21, 30, p. 378) or they are situated in the outside space only, (TL 5.1, fig. 12, 27, 36, p. 378). Therefore, transformation preserves certain patterns of exposure of global scale information and the locations from which this is offered. *However, as analysis showed a general decrease in the numbers of Global Scale convex spaces takes place decreasing the number of views that reach throughout the plans.*

This can be reaffirmed by looking at the Global Scale-Unit index, (TL 5.8, p. 388). At stage three this index is below 0.29 in nine plans[65], (9/12). Therefore, it is not only global scale information that is reduced, but also *the ratio of visual fields that synchronise global scale relations from distance to the total number of visual fields.*

Analysis suggested that each stage retains certain short path units defined in the previous stage, (TL 5.5, fig. 1-36, p. 382). This means that certain parts of the observation route remain the same. However, from one stage to the next there is an increase in the number of the short path units. There is also a random distribution pattern that spreads them throughout the plans. *Thus, transformation extends the exploration pathways necessary to complete an image about the layout as a whole. It also favours the development of a random observation route that is different from floor to floor and from house to house.*

*Visual fields produced from a large number of units are completely different from each other,* Examples of different visual fields produced from different short path units are given in TL 5.7 fig. 3, 4, 7, 8, 11, 12, 19, 20, 30, 31, 33, 34, 39, 40. This is because a large number of short path units are situated inside different convex spaces that are separated from each other by enclosing walls. There are certain units that belong to the same Global Scale convex space or the same Local Scale convex space[66]. In these cases

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65 These are the ground second and third floor of LH1, all floors of LH2, the first floor of LH3, the ground, first and third floor of LH3.

66 The short path units situated along the front surface of the interior at the third floor of LH1, for example, belong to the same Global Scale convex space, (TL 5.5 fig. 12, p. 382). Visual fields from these units are different from each other, (TL 5.7 fig. 9, 10, 12). However, a certain part covering the Global Scale convex space remains invariant. It is interesting to note that in some cases although short path units belong to the same Global Scale convex space, the route from one unit to the next requires movement that steps outside this space. For example the short path units situated on the Global Scale convex space extending at length at the front side of the first floor of LH1 are separated by glass, (TL 5.5 fig. 6, p. 382). The visual fields produced along the route from one of these units to the other change as they loose contact with this space, (TL 5.7, fig. 5, 6, 7).

visual contact with these spaces is retained during movement from the one short path unit to the other, (TL 5.7, fig. 6-7, 13-14-16, 25-26, 26-27, 27-28, 22-24, 22-23, 41-42-43, 45-46-47, p. 385). However, very few units have this property.

In the majority of the layouts a large cluster consisting of large overlap units that share their defining sides is preserved, (TL 5.4, fig. 5-6, 11-12, 14-15, 17-18, 20-21, 23-24, 29-30, 32-33, 35-36, p. 381). This either occupies the outside space, (TL 5.4, fig. 12, 30, p. 381), or it extends from the outside to the inside establishing visual links between interior and exterior through the glazed surfaces of the terraces, (TL 5.4, fig. 6, 15, 18, 21, 24, p. 381).

Some of these units are Global Scale units. Visual fields constructed from these positions are rich and expansive constantly integrating two or more convex spaces, (TL 5.7, fig. 5, 18, 21, 25, 29, 33, 41, p. 385). They also display invariant characteristics as they are produced from a number of units belonging to the same convex spaces. *Thus, a certain degree of successive synchronisation of global and local scale relations and a constant visual contact with specific areas of the plans is always preserved.*

However, the largest part of the layouts is covered by small clusters of small overlap units and by individual overlap units that are isolated from each other by intervening non overlap units and boundary walls. Thus, the majority of the visual fields are restricted to the local scale of a single convex space. Besides, they are different from each other as they offer access to different convex spaces or to different bounded areas. Examples of these differences are given before by TL 5.7 fig. 3, 4, 7, 8, 11, 12, 19, 20, 30, 31, 33, 34, 39, 40, (p. 385).

Finally, visual fields produced from the overlap units mainly synchronise two to three convex spaces. This can be seen by looking at the distribution of colours in TL 5.4, (p. 381). As the figures in these tables show the majority of the overlap units are marked by the range of the light purple hues indicating a small number of convex spaces to which overlap units belong.

It turns out that these layouts create a distinction between two kinds of visual fields: the first kind is about expansive ones transmitting simultaneous information about global and local scale relations that stays invariant over a number of steps. The second kind is about restricted ones transmitting information about local scale relations that constantly changes.

The restricted character of visual information becomes more obvious by looking at TL 5.3, (p. 380). This table shows that a large part of the layouts is described by Local Scale convex spaces that do not overlap with Global Scale convex spaces. Therefore, this part transmits only local scale information.

The changing nature of visual fields can be also observed by looking at the Invariance-Value index of the most connected units. At stage one nine plans have an invariance value index over 0.51[67], (9/12), (TL 5.10, p. 390). At stage two nine plans have an index that is below 0.43[68], (9/12). Finally, at stage three the invariance value index is below 0.37 in eight plans[69], (8/12). In this respect, the ratio of the spatial units that are visible from the most connected units to the total number of units becomes systematically reduced. Consequently, the number of visual fields that offer access to the same units to the total number of visual fields is also reduced. This shows that there is no spatial location that stays invariant over a large number of spatial steps.

- **SPATIAL PROPERTIES AND INTELLIGIBILITY**

To summarise, analysis showed that certain Global Scale convex spaces, Global Scale units, overlap units, short path units and most connected units are preserved during the transformation process. However, from one stage to the other there is a decrease in the number of Global Scale convex spaces, in the Global Scale unit index and the invariance value index. There is also an increased separation of overlap units and short path units with boundaries affecting the relationships amongst these units from stage to stage. *These observations seem to suggest that although certain patterns are preserved, there is an emphasis in directing the space in process away from the properties of the first stage.*

At this stage the layouts constantly provide large scale visual fields. However, although they seem to be easily graspable, they are not directly exposed as wholes from a single position. The obliteration of the spatial properties during the following stages accentuates the lack of a large degree of exposure through minimum spatial points. Thus, the layouts do not accommodate any certainty emerging from standing at few points and receiving a total picture. *To obtain a complete picture the viewer has to move and see as many spaces as possible.*

Although certain large scale views connecting the interior with the terraces are preserved, the information received is often restricted to the local scale articulation. The pathways from the inside to the outside provide visual fields that change from contraction to expansion, (for example see fig. 29-32 in TL 5.7, p. 385). From the former vision embraces very little at a time. From the latter it enables stationary appreciation.

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67 These are the ground, first and second floor of LH1, the first floor of LH2, both floors of LH3 and the first, second and third floor of LH4.

68 These are the ground, the second and third floor of LH1, both floors of LH2, the ground floor of LH3 and the ground, first and second floor of LH4.

69 These are the ground, second and third floor of LH1, the first floor of LH2, both floors of LH3 and the ground and first floor of LH4.

| | LH1 | | | LH2 | | | LH3 | | | LH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 1 | 0.29 | 0.06 | 0.23 | 0.29 | 0.28 | 0.88 | 0.53 | 0.33 | 0.42 | 0.21 | 0.06 |
| 1ST | 1 | 0.71 | 0.50 | 0.17 | 0.32 | 0.15 | 0.71 | 0.60 | 0.05 | 0.80 | 0.25 | 0. 20 |
| 2ND | 0.57 | 0.31 | 0.20 | | | | | | | 1 | 0.33 | 0.29 |
| 3RD | 0.38 | 0.26 | 0.25 | | | | | | | 1 | 0.26 | 0.22 |

Table L 5.8
**GLOBAL SCALE - UNIT INDEX,** (No of Global Scale - Units / Total No of spatial units)

| | LH1 | | | LH2 | | | LH3 | | | LH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAGE | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| GR | 1 | 0 | 0 | 1 | 0.11 | 0.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1ST | 0 | 0.14 | 0.09 | 0.31 | 0.10 | 0.07 | 0 | 0 | 0 | 0 | 0.10 | 0.08 |
| 2ND | 0 | 0.36 | 0.18 | | | | | | | 1 | 0 | 0 |
| 3RD | 0 | 0.08 | 0.03 | | | | | | | 0 | 0.17 | 0.15 |

Table L 5.9
**SYMMETRY SPATIAL UNIT INDEX, (BF),** (No of symmetrical spatial units / Total no of spati units).

There are certain moments in which neither of the two categories of visual fields allow awareness of the other. From the narrow passages and the enclosed spaces defined by the interlocking and twisting surfaces there is hardly any external reference to the terraces. There is hardly any reference to the other spaces of the interior.

Contrasting moments of expansion and contraction, of openness and closeness, of visual exposure and intricate local scale elaboration construct a rhythm of permanence and rapid change in visual reception. *This rhythm makes the experience of the layouts a journey through different spatial episodes. Intelligibility of the system as a whole is possible only after an observer has completed this journey and has learnt the layout through movement.*

Changes in visual fields occur not only along the horizontal but also along the vertical exploration of the houses. As analysis shows although expansive views are maintained, the positions these are offered from vary from floor to floor and from house to house. At the ground floor of LH2, for example, large scale views that connect the inside with the outside are constructed at the front of the layout, (TL 5.7, fig. 18, p. 385). At the first floor of the same house they are transmitted from the right side of the plan, (TL 5.7, fig. 21, p. 385). The same observation applies to the first and second floor of LH4, (TL 5.7 fig. 37, 41, p. 385). Moving from the one floor to the other the positions from which one can see the whole length or width of a layout change from the left to the centre of the composition.

*Thus, it is not only each space that looks different from each other. It is also each floor and each house that seems to offer a unique spatial experience. In this respect, similalry to the horizontal levels the houses become knowable as wholes through a long journey that covers every single position.*

## • PHYSICAL PROPERTIES OF SPATIAL ARTICULATION

Moving to the physical properties the inquiry extends to the participation of surfaces in visual fields. In this way, the patterns of integration of spatial elements by boundaries can be examined. The ways in which surfaces enter spatial experience contributing to the intelligibility of the layouts will be also clarified.

At stage one the surfaces of the block and the voids are fully visible from the Global Scale convex spaces extending next to them in the majority of the plans, (TL 5.1 fig. 1, 4, 7, 16, 19, 22, 28, 31, 34, p. 378). The high value of the Global Scale-Unit index (above 0.57 in eight plans, TL 5.8), indicates that visual fields in these layouts synchronise surfaces from distance. However, there is never a simultaneous visual access to every single surface from a single point[70].

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70 The only exceptions are the first floor of LH1, the ground and first floor of LH3 and the third floor of LH4, (TL 5.5 fig. 4, 19, 22, 34, p. 382). In LH1 the whole of the outer boundary is made evident from the right side of

From stage one to stage three the decrease in the number of Global Scale convex spaces results in a decrease in the number of the outer surfaces that are seen in full length. Besides, the decrease of the Global Scale-Unit index results in a decrease in the number of visual fields that synchronise the outer surfaces from distance to the total number of visual fields in the layouts.

Analysis suggested that to see the layouts as wholes one has to move extensively visiting a series of enclosed spaces. From these spaces the outer boundary is either not accessible at all[71] or is seen as a set of discontinuous portions. Analysis also showed that a large area in these plans is covered by Local Scale convex spaces that do not overlap with the Global Scale convex spaces, (TL 5.3, fig. 3, 6, 9, 15, 18, 24, 27, 30, 33, 36, p. 380). *In this respect, from these areas there is no simultaneous information about the whole length of an external surface and the rest of the internal surfaces.*

From the Global Scale overlap units and the Global-Local Scale overlap units connecting the inside with the outside space both simultaneous and a successive awareness of the whole length of an outer surface, the surfaces of the voids and certain inner surfaces is offered, (TL 5.7, fig. 5, 21, 25, 26, 29, 33, p. 385). However, the dispersed network of Local Scale overlap units in the interiors showed that visual fields are often limited to the scale of a single convex space. *Therefore, there is no large degree of synchronisation of the inner surfaces.* Besides, as visual fields constantly change transmitting information about a different convex space at a time *contact with the same surface is not retained over a large number of steps.*

It seems that a direct or a successive synchronisation of the outer and the inner surfaces is limited to the areas offering expansive visual fields. In the rest of the areas the relations amongst the outer boundary and the inner surfaces as well as amongst the inner surfaces themselves are not directly or successively observable. Visual information reduced to the local scale articulation conceals the interconnections amongst the global and the local scale physical elements shifting rapidly from surface to surface.

- **PHYSICAL PROPERTIES OF SPATIAL ARTICULATION AND INTELLIGIBILITY**

The analysis of the physical properties of all houses shows that *the lack of a systematic preservation of spatial properties carries with it a lack of systematic preservation of physical properties.* At stage one the

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single short path unit situated at the left side of the interior, (TL 5.5 fig. 4, p. 382). This is because this side coincide with the defining side of two Global Scale convex spaces each of which covers the left or the right side of the plan at width. In LH3 the short path unit situated at the back right corner of both plans exposes the whole layout from its left side for the same reasons with the ones mentioned above, (TL 5.5 fig. 19, 22, p. 382). Finally in LH4 from the common defining line of the two short path units. the whole layout is seen at once, (TL 5.5 fig. 34, p. 382).

71 There are certain enclosed spaces situated in the middle of the plan that are not defined by the outer boundary like the staircase volumes or the service spaces attached to bedrooms, (TL 5.5, fig. 3, 6, 15, 18, 27, 30, 33, p. 382).

| | LH1 | | | LH2 | | | LH3 | | | LH4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STAGE** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| **GR** | 1 | 0.33 | 0.28 | 0.23 | 0.42 | 0.40 | 0.72 | 0.37 | 0.28 | 0.42 | 0.26 | 0.20 |
| **1ST** | 0.62 | 0.57 | 0.46 | 0.51 | 0.40 | 0.22 | 0.66 | 0.43 | 0.22 | 0.53 | 0.30 | 0.24 |
| **2ND** | 0.57 | 0.31 | 0.30 | | | | | | | 1 | 0.42 | 0.37 |
| **3RD** | 0.44 | 0.35 | 0.30 | | | | | | | 0.66 | 0.65 | 0.57 |

**Table L 5.10**
**INVARIANCE VALUE INDEX,** (No of spatial units visible from the most connected units/Total spatial units, including spatial units situated in the voids).

successive exposure of the outer surfaces and the surfaces of the void reveals the physical interconnections of surfaces. One can grasp the spatial and the physical system within a short time. At stages two and three certain outer surfaces assume an integrating role synchronising global and local scale relations. However, in the largest area of the plan only local scale information about the synchronisation of spaces by the outer and the inner surfaces is offered. *Thus, the physical properties of the spatial structure does not seem to aid to the appreciation of the spatial system.* The analysis of spatial properties suggested that intelligibility relies on a large scale promenade. It could be argued that the absence of integrating boundaries relating close and distant spaces together makes this promenade the only alternative.

- **GEOMETRICAL PROPERTIES OF SPATIAL ARTICULATION**

Analysis of each house pointed out that there is no overall symmetry, 'just about' symmetry or local symmetry characterising the geometrical organisation of the various spatial systems in any stage. There are certain exceptions in which weak patterns of local symmetry organise the spatial units, like the second floor of LH1, the ground floor of LH2 and the second and third floor of LH4, (TL 5.5 fig. 9, 14, 33, 36, p. 382, TL 5.9, p. 388). These patterns arise from the placement of particular spatial units on the BF axis rather than from a symmetrical distribution of spatial units on this axis. Besides, some of these units belong mainly to different convex spaces that are surrounded by enclosing boundaries, (TL 5.4 fig. 9, p. 381). Thus, it is not easy to understand their position on the geometrical axis of the plan. This is because there is restricted information provided in these spaces that does not allow one to grasp the geometrical position of the spatial units in relation to the layout as a whole.

- **GEOMETRICAL PROPERTIES AND INTELLIGIBILITY**

The absence of geometrical regularity in spatial organisation shows that there is no symmetry or repetition in the patterns of visual fields. *Thus, there is no way one can grasp the spatial system relyiing on regularity embedded into the structure of visual information.*

To summarise, analysis showed that in Le Corbusier there is restricted global scale information and changing patterns of information transmission. These construct a spatial experience in which there is never a privileged, definitive point of view. There is rarely an interconnection of distant spaces by boundaries. There are no regularised patterns of visual fields either which can navigate the visitor by suggesting principal view points. Intelligibility develops gradually as an observer shifts his position in space. Le Corbusier's houses are found to be fundamentally different from Botta's houses which reveal themselves through small scale exploration and privileged positions. In the section that follows a comparison amongst all eight houses will eventually examine why this is so. It will also try to take the investigation of spatial experience further identifying the ways it gives access to the properties of form.

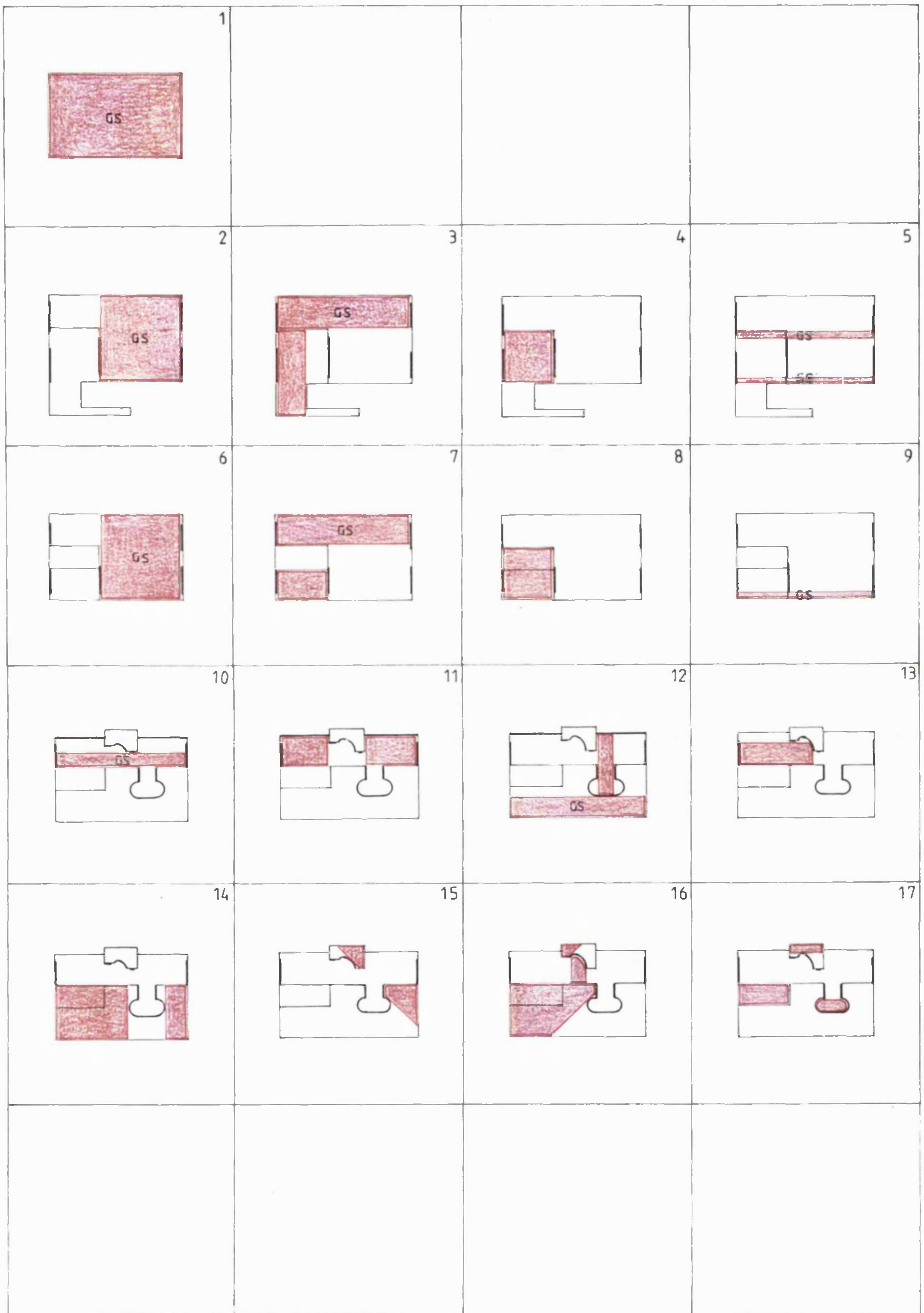


Table LH1 5.10 - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

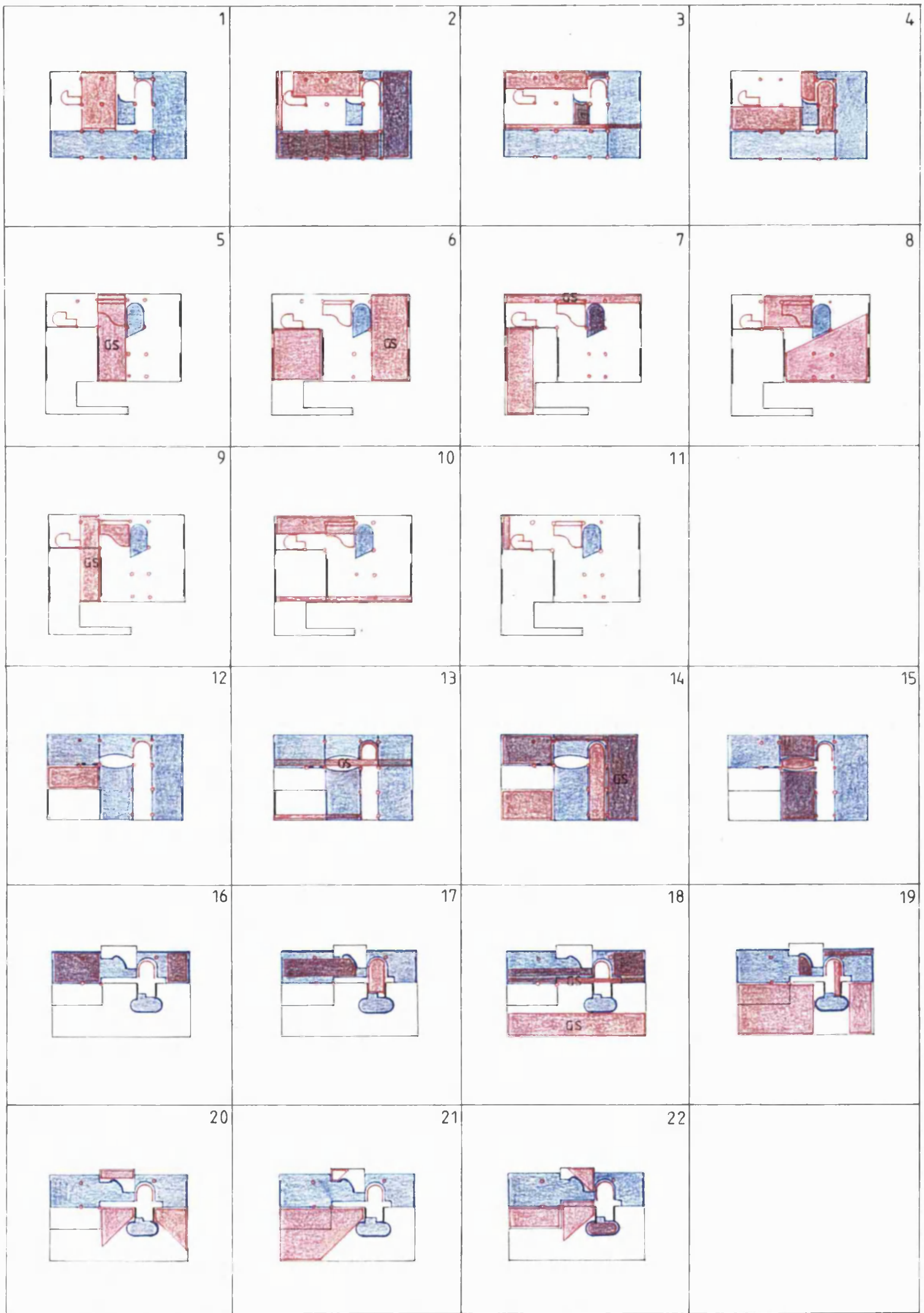


Table **LH1 5.11** - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES

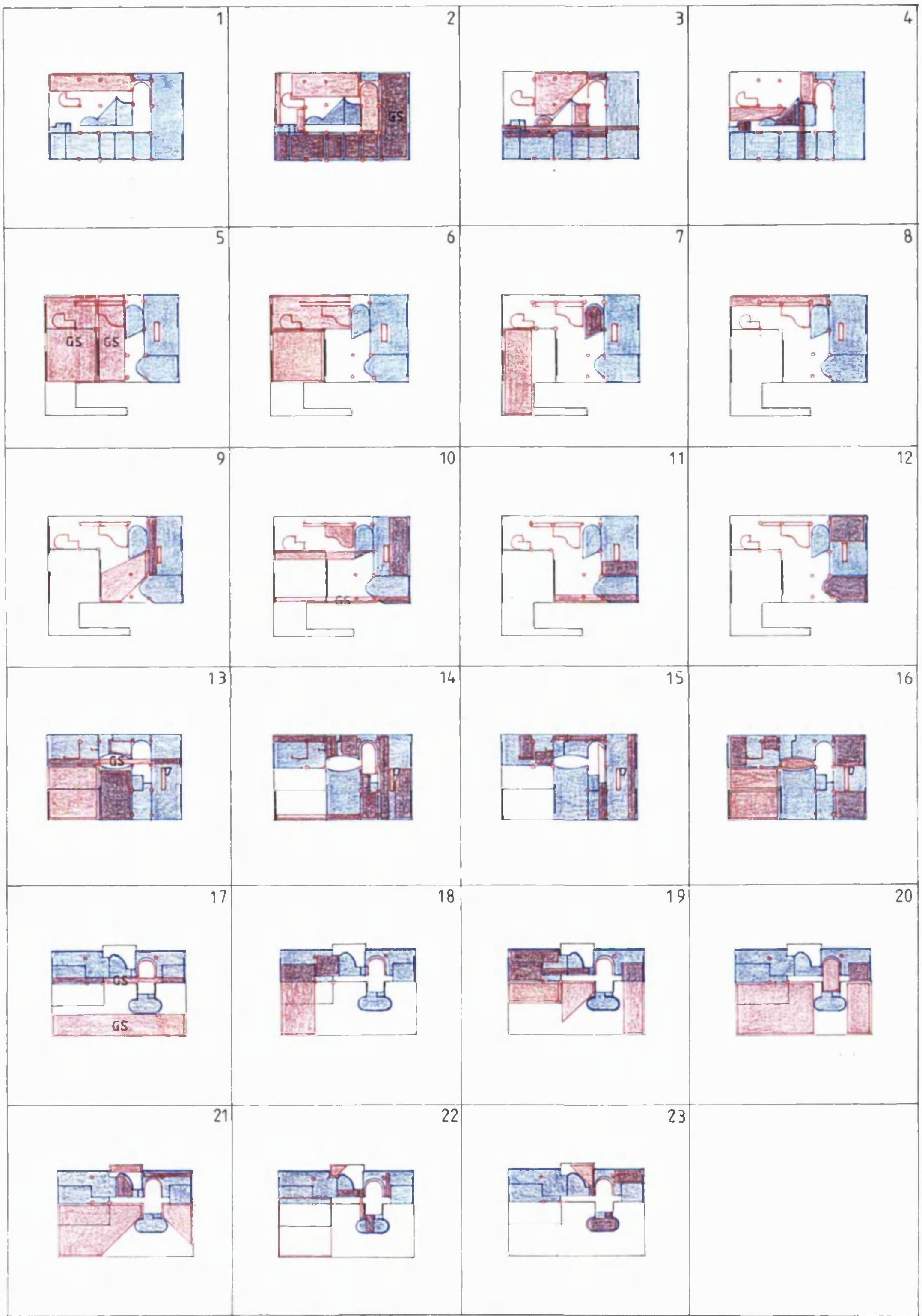


Table LH1 5.12 - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

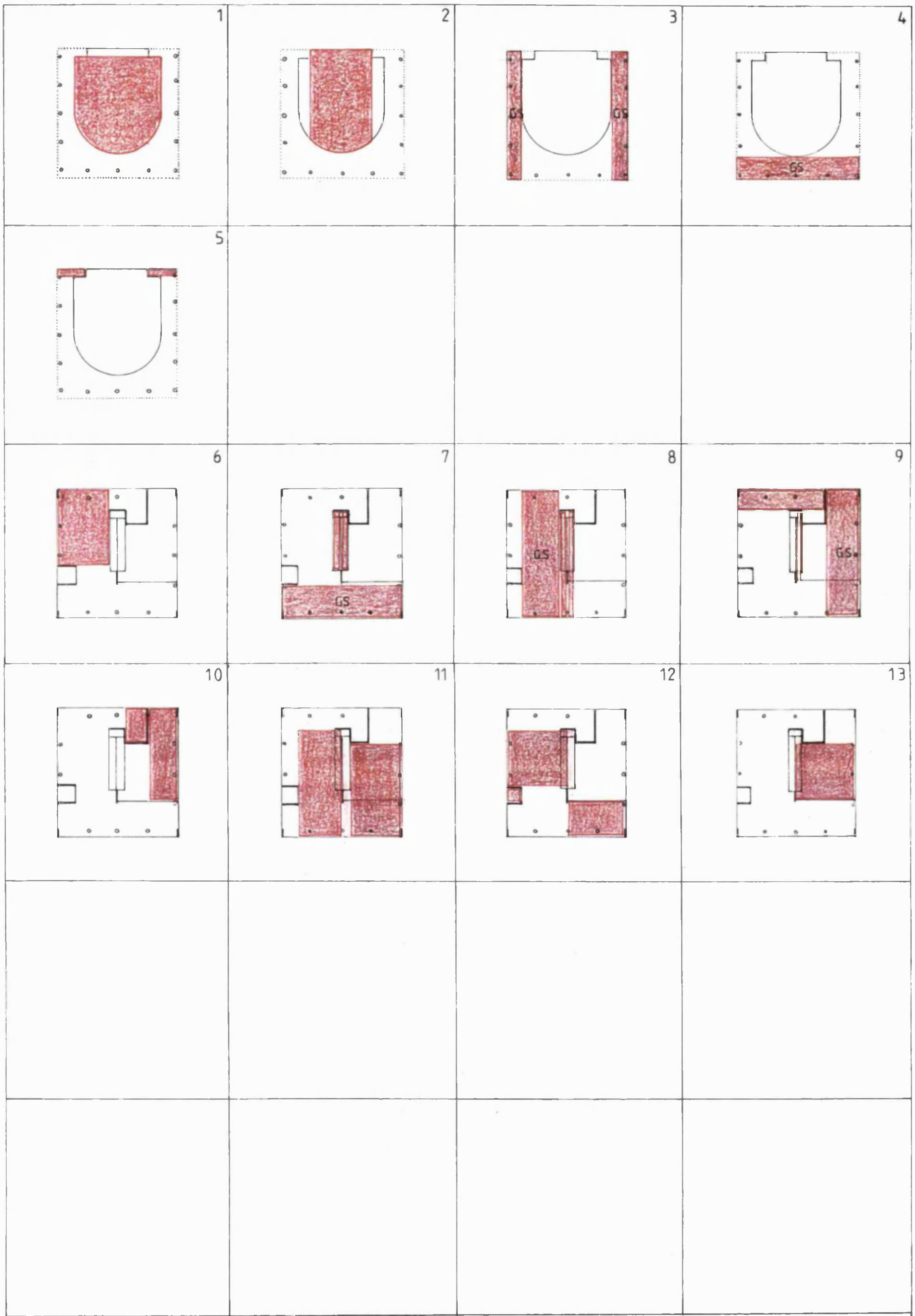


Table **LH2 5.1** - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

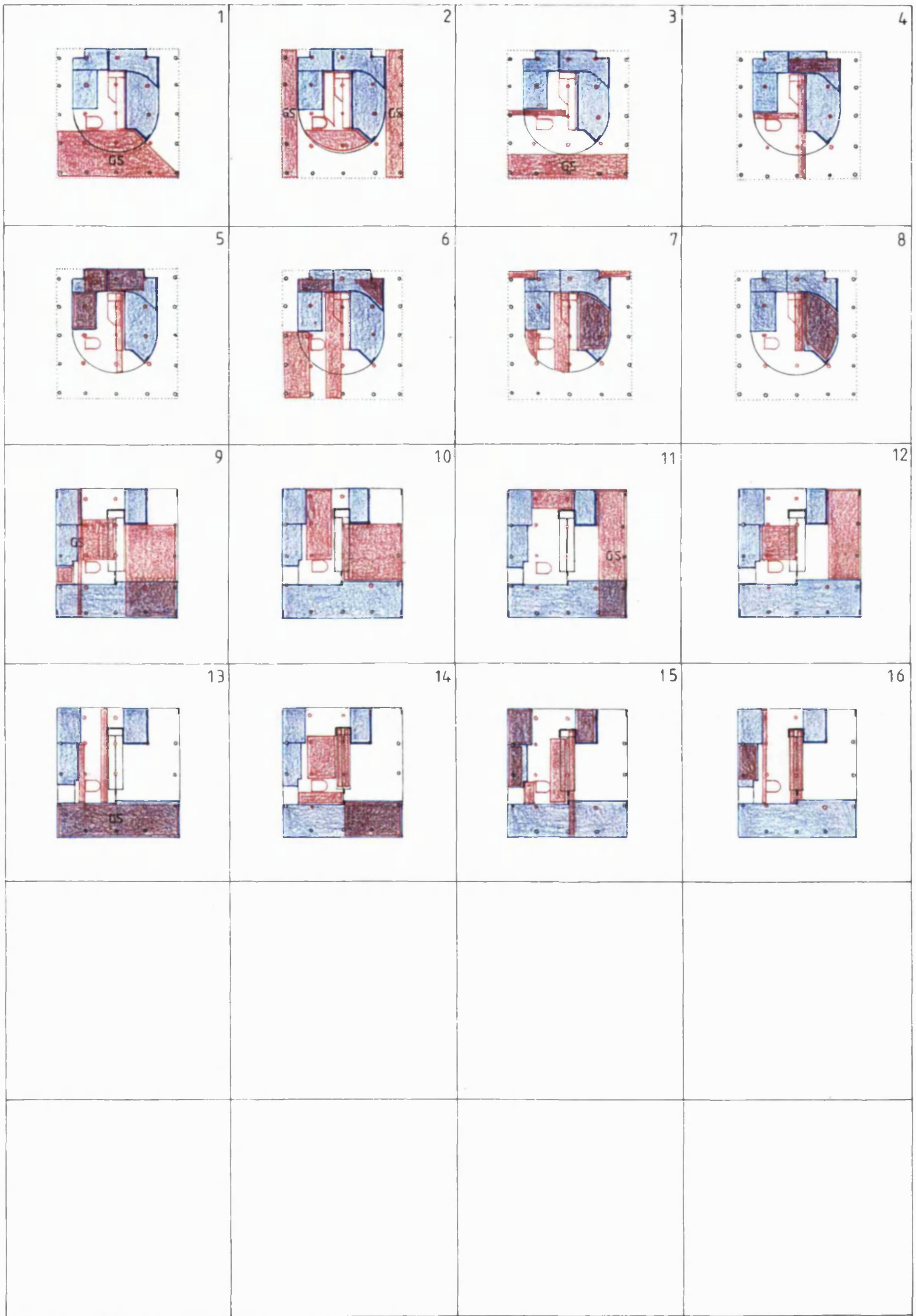


Table LH2 5.2 - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES

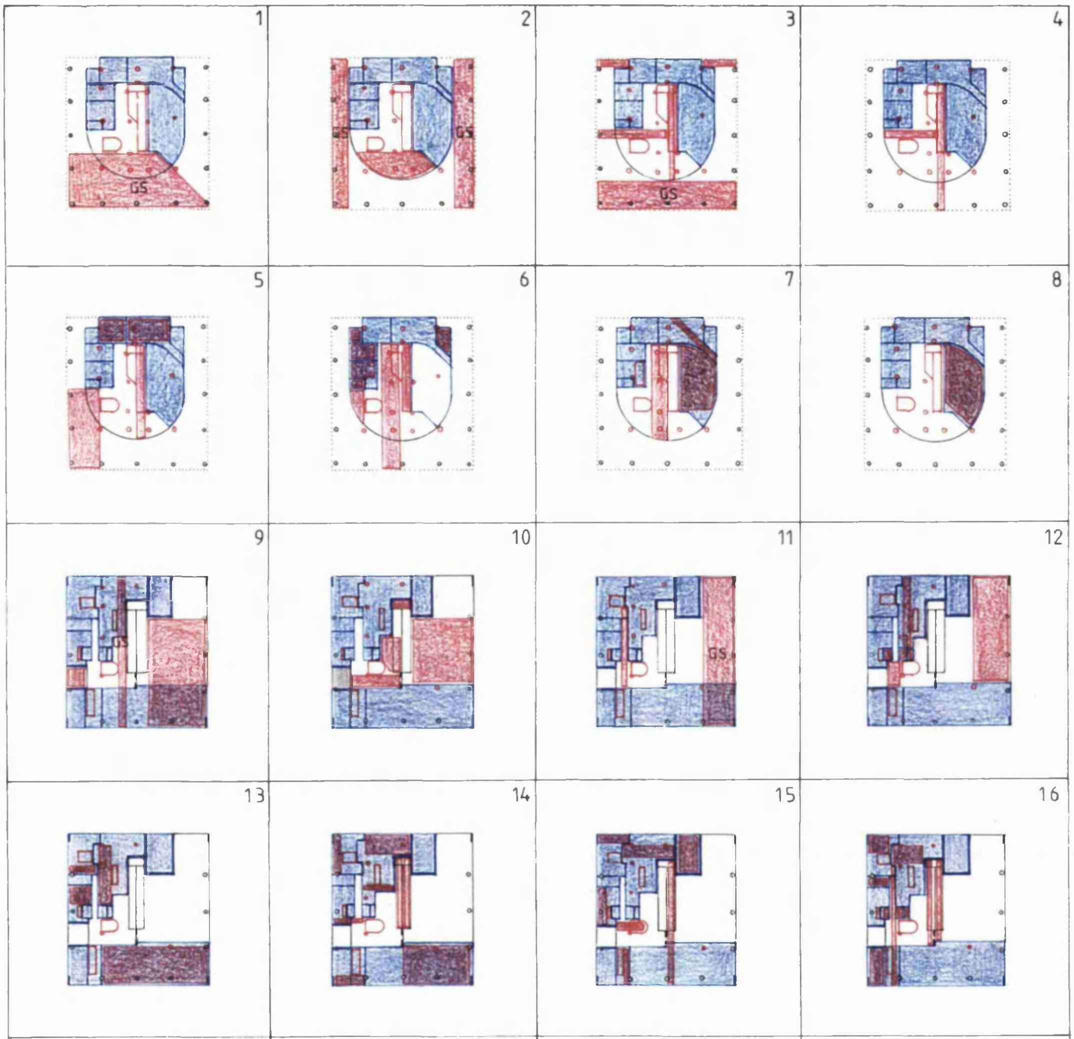


Table LH2 5.3 - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

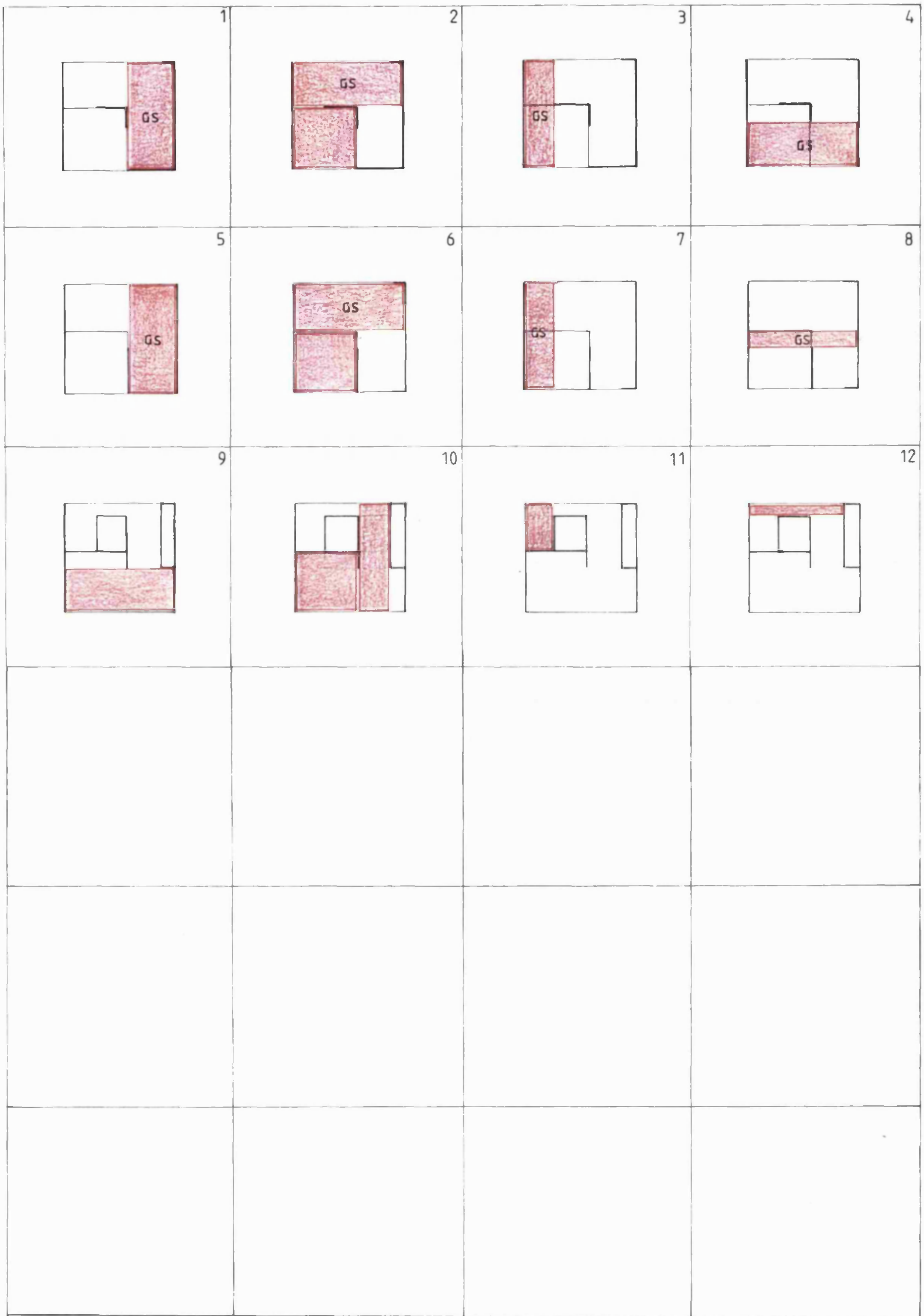


Table **LH3 5.1** - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

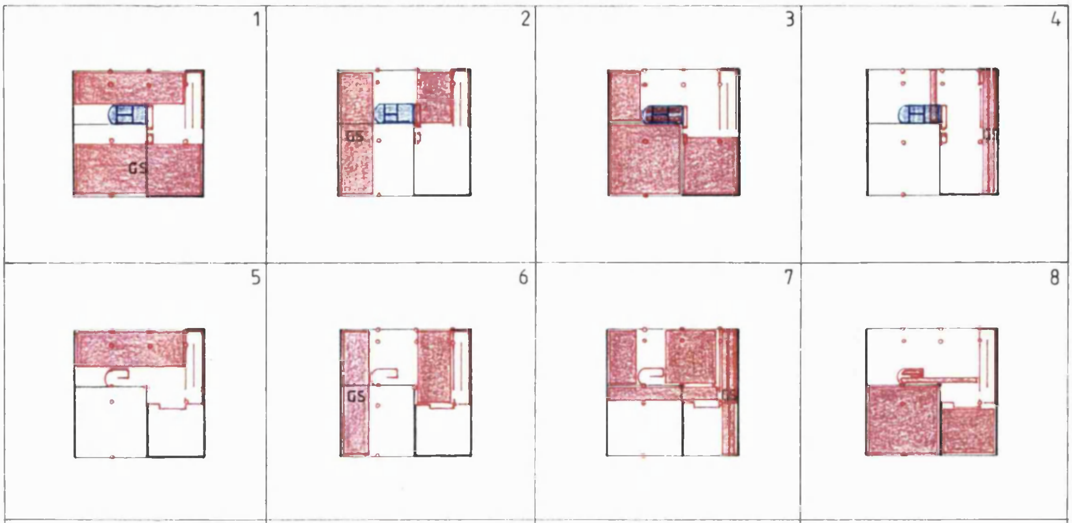


Table LH3 5.2 - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES


Table LH3 5.3 - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

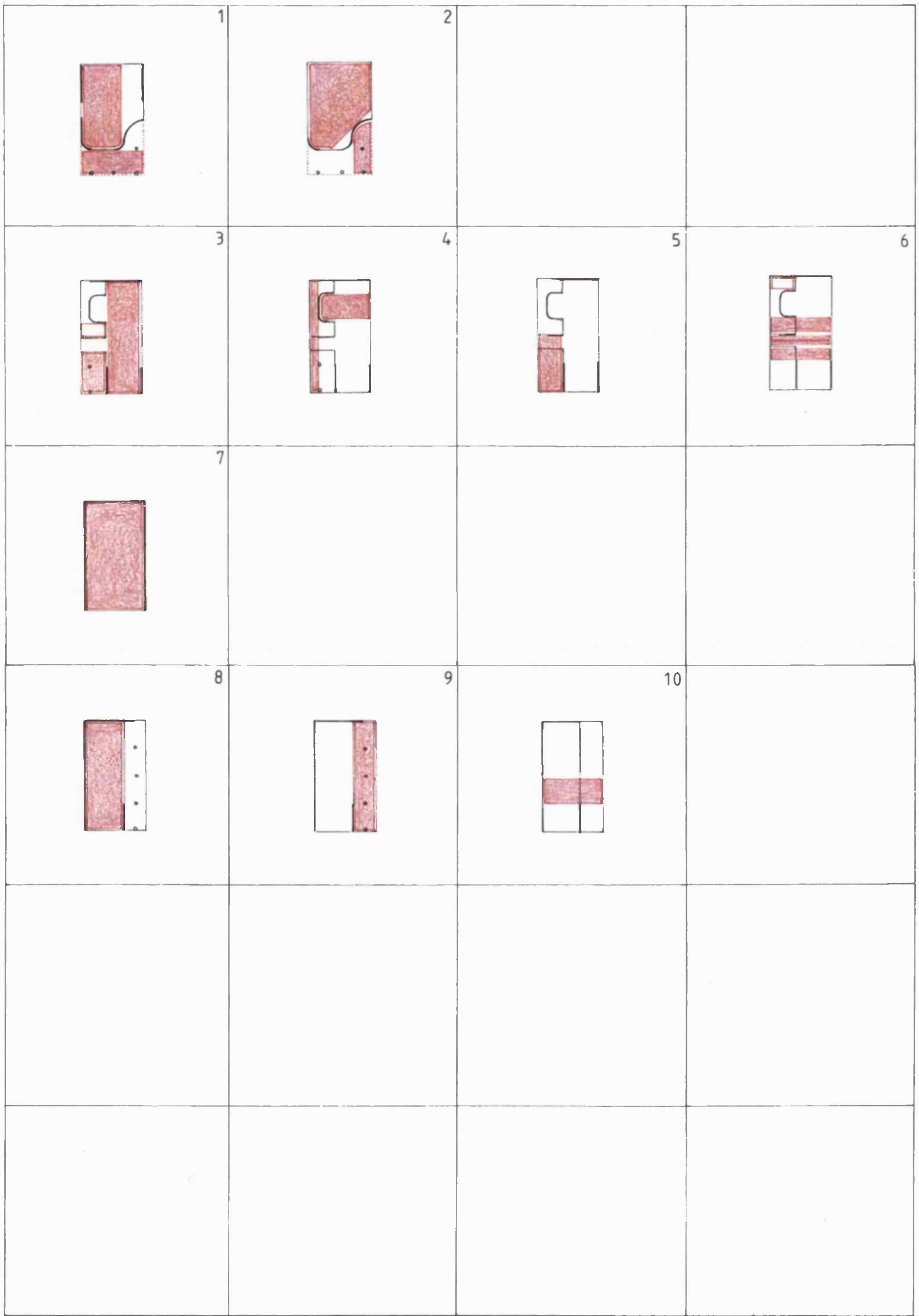


Table LH4 5.1 - Stage One
ANALYTICAL REPRESENTATION OF CONVEX SPACES

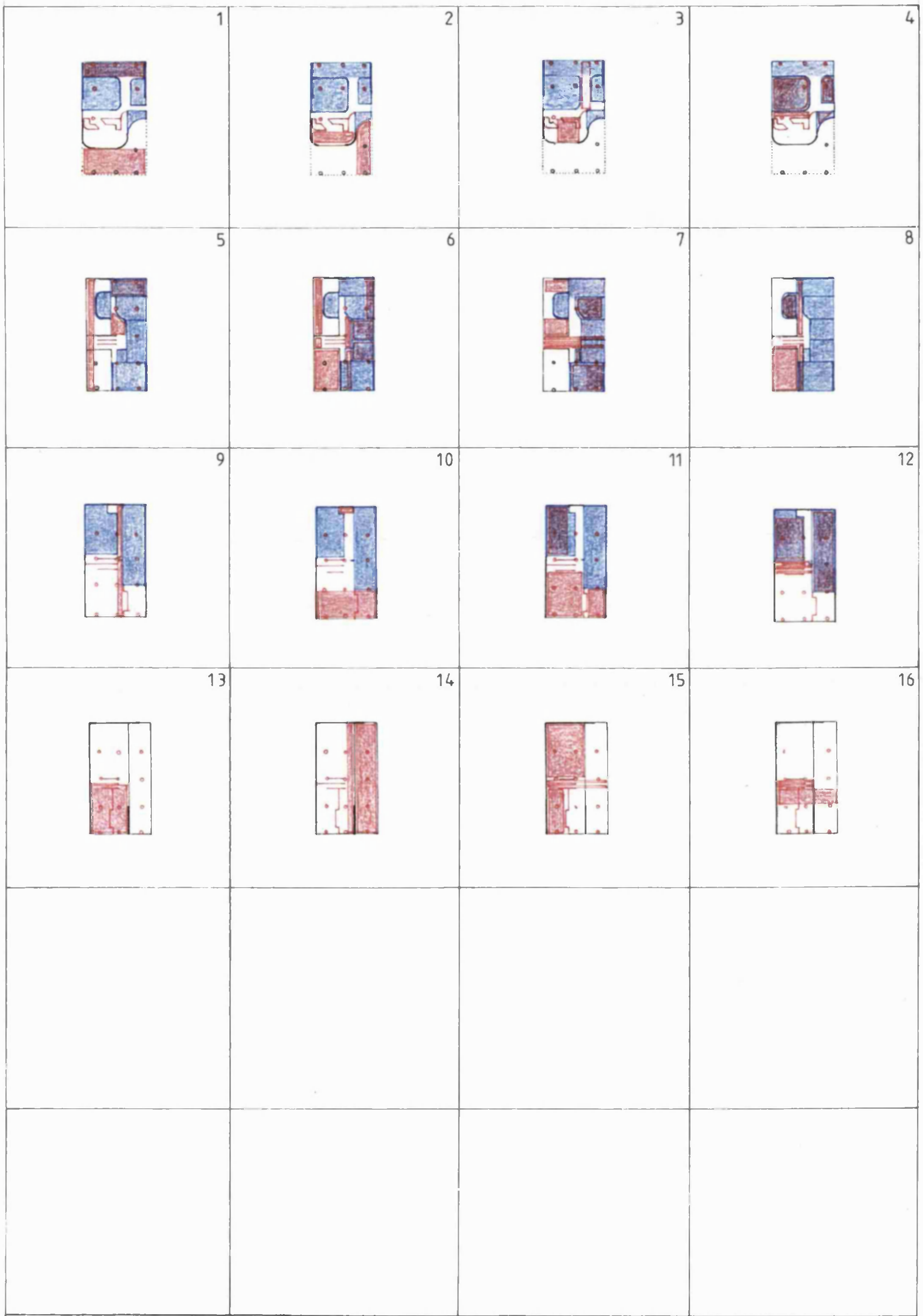


Table LH4 5.2 - Stage Two
ANALYTICAL REPRESENTATION OF CONVEX SPACES

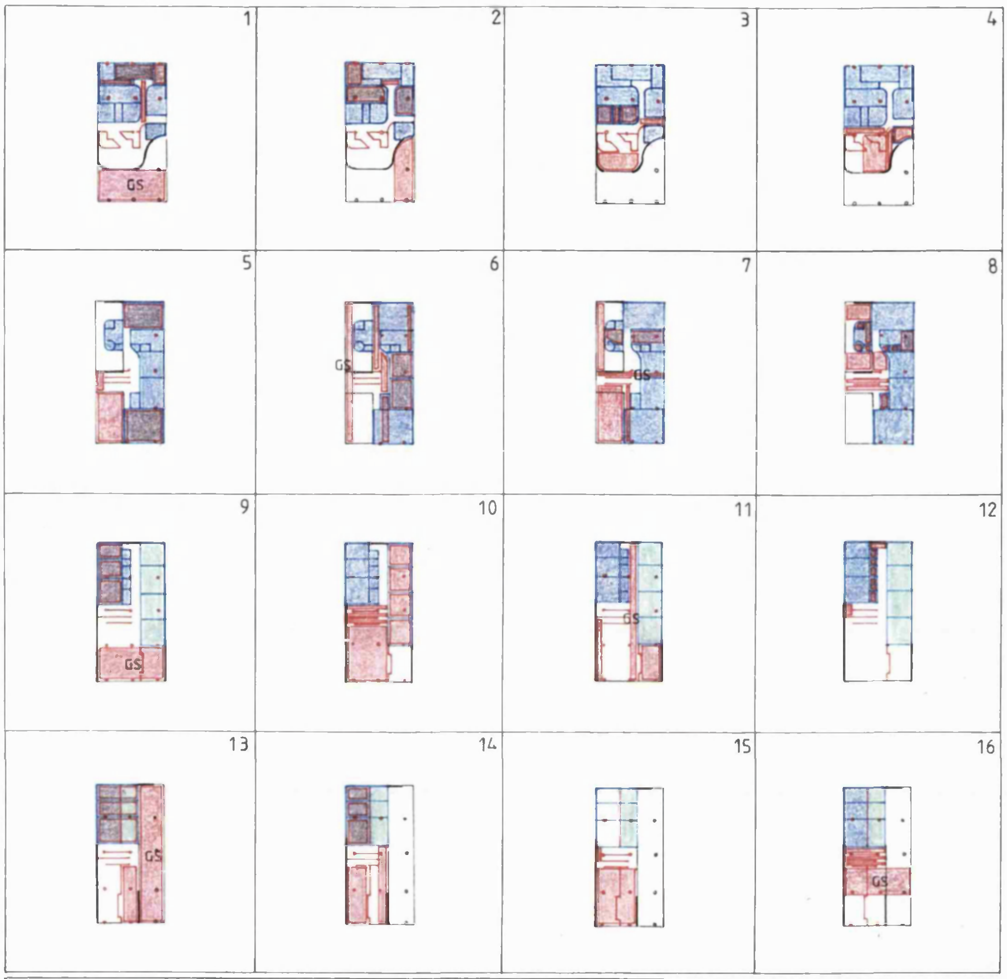


Table LH4 5.3 - Stage Three
ANALYTICAL REPRESENTATION OF CONVEX SPACES

- **COMPARISON BETWEEN BOTTA AND LE CORBUSIER**

The comparison between Botta and Le Corbusier starts by looking at two things: One is the degree to which the architects employ a certain course of action characterised by patterns of occurrence of relations that are stage specific. The other is the ways the type of transformation they employ, a preservative transformation for Botta as opposed to an obliterative for Le Corbusier, affect the intelligibility of the layouts.

Starting with the first parameter analysis observed that regardless of the fundamental differences between their houses the two architects possess fundamental similarities. These are the following:

- Both architects use specific patterns of distribution of spatial elements and specific patterns in which these elements relate to each other. In this respect, they both employ specific strategies of transformation of spatial articulation.
- They both associate certain stages with certain configurational patterns of spatial elements and with certain locations these elements occupy on the plans.

*Thus, analysis suggested that both Botta and Le Corbusier possess a specific design logic based on a specific course of action. A design strategy that is consciously applied shows that both architects articulate the space in process aiming at a specific kind of spatial experience.*

- **THE RELATIONAL LOGIC OF TRANSFORMATIONS**
- **Positions of spatial elements on the plans**

Analysis also showed that although the two architects associate certain stages with certain elements and certain positions, they have a different approach regarding the positioning of spatial elements on the plans.

In Botta the majority of the Global Scale convex spaces, the Global Scale units, the overlap units, the short path units and the most connected units are always situated at the same locations. These are the area around the BF axis, the front side, the left or both the left and the right sides of the plan. In Le Corbusier the positions of certain elements are kept invariant throughout the stages. However, they vary from floor to floor and from house to house. Besides, the majority of the spatial elements are randomly distributed on the plans occupying a different position in each case.

It seems that Botta applies a specific spatial articulation in every house. Spatial patterns develop according to an ordered distribution of spatial elements on specific locations. Le Corbusier applies less strict rules. He uses a random distribution of elements and changes their positions from floor to floor and from house to house.

These differences are intrinsically related to the different ways in which the two architects approach transformation. It has been suggested that *Botta tends to bring the properties of every stage close to those of the first stage. On the other hand, Le Corbusier adopts both a preservative and an obliterative mode of transformation. Nevertheless, the latter is more prominent taking spatial properties away from the properties of the first stage.*

Botta constantly directs his design process to space that has certain characteristics. Le Corbusier introduces more randomness into the design allowing space to develop during a process and relations to be crystallised at the final stage. Botta imposes a specific spatial order into the transformation of space. Le Corbusier challenges this order by more probable and random configurations emerging during design. Thus, it could be suggested that Botta has a specific notion of spatial articulation based on pre-existing rules. Le Corbusier has a specific notion of spatial articulation the rules of which are allowed to develop following the development of the space in process.

The different approaches to transformation have different effects in the ways their houses are revealed during spatial experience. Thus, analysis showed that Botta's houses are revealed from limited points of view that immediately release large chunks of information. On the other hand, Le Corbusier's houses are revealed through a large exploration route that gradually exposes small scale information.

The comparative examination of the houses of each architect concluded that *on the one hand, Botta's buildings become graspable within a short time. On the other hand, Le Corbusier's buildings become graspable sequentially over an extensive length of time.*

Grasping a sequential medium like space means that certain mental processes at work lead to an interpretation about the structure of this medium as a whole. The two architects seem to create two different kinds of processes. One is almost immediate, the other one is sequential. The questions to ask next are:

- *How these building solicit two different processes of cognition and how these processes are structured? i.e. How these buildings cue the viewer to execute a definable system of operations that lead to two different kinds of grasping and which are these operations?*
- *How the spatial-formal interaction shapes these processes? How the viewer's grasping of space is affected by the formal properties that give form and shape to this space? How he detaches himself from the spatial environment he grasps from within to experience the formal system conceived from without?*

- **Cognition as an operational process**

Starting with the first question it is necessary to define what are the mental processes that are set at work in spatial experience and how a building cues an observer to execute a set of mental operations. An inquiry on the notion of geometrical transformation carried out in chapters one and two lead to the suggestion that understanding develops through the retrieval of higher and lower levels of articulation based on observations of properties that remain invariant across these levels. Intelligibility, it was argued, develops based not on static concepts but on dynamic ones. It emerges out of operations in which global scale relations are extrapolated from observations of invariant properties in the local scale.

In other words, intelligibility of a pattern, i.e. knowledge of the ways its local elements come together to form a whole, is a part of a more general process that is operational in nature following the operational structure of transformation. It could be argued that intelligibility is the outcome of an operational process of cognition which activates mental operations. These operations are about extrapolations of the global scale relations from observations of invariant properties in the local scale.

This study has also suggested that there is a fundamental difference in understanding geometrical patterns seen on paper and understanding a spatial organisation. In the former both the higher and the lower levels are visually present. Regardless of the difficulty in reaching an interpretation that some visual patterns generate[72], everything is made available to vision at a single glance. On the other hand, intelligibility of spatial patterns is determined by the restricted nature of vision that accesses only limited amount of information at a time. In spatial experience the higher and the lower levels do not make themselves available at once. They unfold gradually as the experience develops.

Thus, in experiencing spatial patterns the operational processes of understanding are prolonged as piecemeal information enters the field of vision withholding the final interpretation. Nevertheless, the hypothesis formulated is that the principles by which intelligibility is structured in space remain the same, i.e. global scale relations are induced by invariant characteristics received through local scale observations.

To explain these suggestions better one may look again at the layout presented in figure 5.19, (p. 319). It has been suggested that the common surface linking the two rooms together expresses their spatial relation. Local observations constructed from the individual spaces reveal information about how their surface extends beyond the local scale articulation to suggest a large spatial rectangle. This information does not expose the global organisation at once. It enables the formulation of a hypothesis, or of one

72 Analysis of some elementary configurations as well as the analysis of the formal properties of the volumetric and the plan articulation of Le Corbusier's buildings showed that such difficulty is related to a multiple distribution of elements into different layers of structure. This generates a multiplicity in interpretation rather than a single and straight forward reading.

possible interpretation amongst potential ones. In other words, it offers a 'cue' for what the global scale is about.

In the visual fields produced as an observer moves from the one space to the next the binding surface is constantly present. The invariant role of this surface reaching out to complete the spatial rectangle sustains the hypothesis formulated previously leading to a final interpretation. The formulation of the hypothesis and its validation form the operational set of intelligibility.

If by moving into the second space the observer receives new evidence that contradicts his previous understanding, like for example in figure 5.20, (p. 319), his interpretation about a large space subdivided into two individual spaces has to be readjusted. What seemed as a spatial rectangle turns to be a spatial L with a dividing surface. The old interpretation and the new one interact pointing at a new direction.

Thus, cognition of spatial patterns as an operational process is based on an operational set of hypothesis forming and hypothesis testing. Picking up information in a layout activates an inferential process subjected to further interrogation as the experience unfolds. Lower and higher levels, i.e. information received locally and interpretations about the global level interact and readjust themselves according to the degrees of invariance built into the field of vision.

The notion of hypothesis-forming and hypothesis-testing has been also put forward by Gombrich. According to Gombrich the organism interrogates the environment for information which is then checked against the perceptual hypothesis. However, in the literature review chapter it was suggested that Gombrich dislocates intelligibility from the physical object assigning interpretation to the inquiring subject. This thesis based on the suggestion that intelligibility is determined by the properties of the object proposes that the operational set structuring intelligibility is built into the operational set of the pattern. In other words, into the properties that remain invariant.

However, analysis also showed that there are cases in which global scale information is instantly transmitted. A single bounded convex space, for example, exposes and renders itself intelligible at once. An overlap unit integrating two convex space does the same. These cases are about a synchronisation of global and local scale relations that immediately reveals the spatial pattern. Although they are rarely experienced in real buildings, analysis of Botta showed that in the first floor of his houses a similar kind of situation takes place in which the layout is seen almost as a whole.

Thus, two different ways in which spatial patterns can be intelligible are identified. One refers to a synchronisation of global and local scale characteristics, whereas the other one to invariant characteristics built into visual fields that change in the course of movement. However, the distinction between synchronisation and invariance is not as simple and as straight forward as presented here.

In the layout in figures 5.19 and 5.20, (p. 319), there is a certain degree of synchronisation expressed by the spatial connection amongst the two spaces as well as by the binding surface. Besides, synchronisation of relations in the single convex space is also about invariance in the sense that no matter how an observer shifts his position, the same amount of information enters his field of vision. However, whereas in the convex layout there is synchronisation of global and local scale characteristics and global invariant characteristics in the sense that the total set of relations are made available and stay invariant in perception, in the layout in figures 5.19 and 5.20 it is only local characteristics that are synchronised and are preserved. This is because it is only the connection of the two spaces in relation to a single surface that is exposed and stays constant.

Therefore, understanding a layout seems to be about an operational process which works in two directions. One direction captures synchronisation, i.e. the interconnections amongst elements. The other one captures the degree to which these interconnections remain invariant in the course of changing information. The former reveals information, the latter repeats information over a number of steps. The former seems to refer to the degrees to which the global scale can be extrapolated out of local scale observation. The latter refers to the degree to which global scale observation produced my moving around is extrapolated based on the properties that remain invariant. Synchronisation and invariance set mental mechanisms at work that formulate and test hypotheses. They interact in the course of spatial experience cueing the observer to construct a set of hypotheses and interpretations that are in a constant state of mutual interrelation and negotiation.

This distinction forms the analytical mode for examining the eight houses. The questions that are asked are: What kinds of synchronisation and invariance an observer encounters in the experience of these houses and how these influence his grasping? Thus, analysis re-examines the analytical material in terms of these two perspectives: Intelligibility based on synchronisation of properties and intelligibility based on invariant properties.

To answer these questions a comparative examination of the spatial, the physical and geometrical characteristics of spatial articulation the two architects employ is needed.

## • THE SEQUENTIAL EXPERIENCE OF SPACE AND THE PROCESS OF COGNITION

This part of the analysis looks at the degrees of synchronisation and invariance offered in the experience of the layouts. More particularly, it looks at how patterns of visual synchronisation and invariance can *reveal* or *cue* the observer to build a picture about the layout as a whole.

### • Synchronisation of spatial, physical and geometrical properties and spatial experience

In this section the layouts are examined in terms of the degrees of synchronisation established amongst spatial relations and their physical and geometrical characteristics. Therefore, the eight houses are examined in terms of the patterns of spatial systems accounting for this synchronisation. These are: Global Scale convex spaces, Global Scale units, Global Scale-Unit index, overlap units, short path units and invariance values.

### • Global Scale convex spaces

Botta preserves the central Global Scale convex space at width, (TB-L, 5.1, fig. 12, 15, 17, 21, 23, 27, 33, 36, p. 411), one or two Global Scale convex spaces on either side of this space,(TB-L 5.1, fig. 3, 5, 9, 17, 23, 27, 30, p. 411), the Global Scale convex space at the right, (TB-L, 5.1, fig. 9, 15, 36, p. 411), or at both the left and the right side of the plan, (TB-L, 5.1, fig. 23, p. 391) and the one extending at length at the front of the composition, (TB-L 5.1, fig. 3, 5, 9, 12, 15, 23, 27, 33, p. 411). Le Corbusier preserves only the Global Scale convex space at the left or at the right side and the one extending at length at the front of the layouts, (TB-L, 5.1, fig. 1-36, p. 411). *Thus, Botta preserves and exposes a large degree of global scale visual information. On the other hand, Le Corbusier tends to eliminate this kind of information.*

Looking at the distribution of colour in TB-L 5.1 some further dimensions in the differences in the Global Scale convex structure between the two architects can be demonstrated. At stage three in the first and second floor of BH1, the second floor of BH2, the first and second floor of BH3 and the ground and first floor of BH4 a large area of the plan is covered by Global Scale convex spaces, (TB-L 5.1, fig. 5, 9, 17, 23, 27, 30, 33, p. 411). In Le Corbusier very few plans have this property. These are the first floor of LH1 and LH3, (TB-L 5.1, fig. 42, 57, p. 411). Therefore, in Botta's there is a larger area from which global scale information is obtained.

The effects of the Global Scale convex space structure to the physical constitution of visual fields is such that in Botta the left, the right or both the left and right outer surfaces are exposed in their entire length from the Global Scale convex spaces extending in those locations. In Le Corbusier it is only the left, the right and the front surface that are seen in full length. Thus, in Botta there is usually a larger number of outer surfaces that are experienced as physically continuous elements than in Le Corbusier.

- **Global Scale units**

The differences between the two sets of houses regarding the degree of global scale information they offer can be also observed by looking at the Global Scale unit index. The value of this index in Botta remains over 0.40 in ten plans, (10/12), (TB 5.10, p. 349). In Le Corbusier it drops below 0.29 in nine plans, (9/12), (TL 5.8, p. 368). *Thus, Botta retains a larger number of visual fields that reach throughout the plan in one or in two directions than Le Corbusier. Besides, he retains a larger number of visual fields that synchronise the outer surfaces from distance.*

- **Overlap units**

In Botta a dense and continuous network of overlap units covers the largest part of the layout, (TB-L 5.4, fig. 3, 5, 9, 15, 17, 23, 30, 33, 36, p. 414). In Le Corbusier clusters of overlap units and individual overlap units are scattered throughout the layout covering a small area of the plan, (TB-L 5.4, fig. 3, 9, 12, 15, 18, 24, 27, 30, 33, 36, p. 414). The overlap units in Botta share their defining sides. In Le Corbusier they are often separated from each other by non overlap units and enclosing walls. *Thus, visual fields in Botta constantly and successively synchronise a number of convex spaces. Visual fields in Le Corbusier often offer access to a single convex space.*

This can be demonstrated by looking at the pattern of colour distribution. In Botta the coloured areas cover a large part of the layouts. In Le Corbusier apart from the first floor of LH1 and the ground floor of LH3, (TB-L 5.4, fig. 42, 57, p. 414), colour covers a smaller part of the plans. Besides, in Botta there are plans covered by the deepest hues of the purple range showing that there are more than ten convex spaces that are simultaneously seen, (like the second floor of BH1, the ground and first floor of BH4, TB-L 5.4, fig. 9, 30, 33, p. 414). In Le Corbusier most of the plans are covered by light purple constructing a synchronisation of mainly two or three spaces. The only exceptions are the first floor of LH1, the ground and first floor of LH2 and the ground and first floor of LH3 where some overlap units synchronise five to seven convex spaces, (TB-L 4, fig. 42, 51, 54, 57, 60, p. 414).

The majority of overlap units in Botta are Global Scale overlap units and Global-Local Scale overlap units. A large number of overlap units in Le Corbusier are Local Scale overlap units. Thus, in the former there is constant overlap constructed amongst the Global Scale convex spaces and the Local Scale convex spaces as well as amongst the Global Scale convex spaces themselves[73], (TB-L 5.2, fig. 1-36, p. 412).

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73 The only exception in Botta is the ground floor of BH3 in which the largest part of the plan is covered by units that belong to convex spaces that do not overlap with Global Scale convex spaces, (TB-L 5.3, fig. 21, p. 413).

In the latter a large part of the layouts is covered by Local Scale convex spaces that do not overlap with Global Scale convex spaces[74], (TB-L 5.3, fig. 1-36, p. 413).

*Botta constructs a constant and successive synchronisation of global and local scale relations. This results in a successive synchronisation of the outer and the inner surfaces. Le Corbusier often disconnects the global scale elements from the local scale ones. Thus, there is a large area of the plans where visual fields synchronise only the surfaces of a single convex space. Besides, there are areas where visual fields are constituted only by the inner surfaces.*

- **Short path units**

In Botta the multiple intersections amongst Global Scale convex spaces result in a central short path unit from which the first floor of BH1, BH3 and BH4 and the ground and second floor of BH2 together with their defining outer and inner surfaces are almost seen as wholes, (TB-L 5.5, fig. 5, 12, 17, 23, 33, p. 415, see also TB 5.7, fig. 5, 12, 17, 23, 33, p. 417 provided in the comparative examination of Botta's houses). Some of the rest of the floors are seen through an economical and ordered short path progressing from the back to the front at the centre of the plan, (TB-L 5.5, fig. 3, 9, 30, p. 415).

In Le Corbusier there is not a large number of intersecting Global Scale convex spaces. Therefore, there is no single position exposing the layout as a whole. On the contrary, there is a large number of short path units that spread in random arrangements throughout the plan, (TB-L 5.5, fig. 1-36, p. 415). A large number of these units releases a small amount of visual information. *Thus, spatial and physical exposure in Botta is either offered immediately[75] from a single position or provided from a short and ordered route. In Le Corbusier exposure is piecemeal, delayed, widely and randomly distributed throughout the plan.*

In Botta the visual fields constructed from the central short path units at the first floor of BH1, the ground and second floor of BH2, the first floor of BH3 and BH4 are symmetrical or almost symmetrical on the BF axis, (see, TB 5.7, fig. 5, 12, 17, 23, 33, p. 417 in the comparative examination of Botta's houses). Further, from a large number of short path units situated on either side of the BF axis symmetrical or almost symmetrical views are released, (TB-L 5.8, fig. 3-4, 35-36, 39-40, p. 418). In Le Corbusier there are no symmetrical visual fields produced from any position in the layout, (TB-L 5.8, fig. 49-95, p. 418). Therefore, in Botta global scale spatial physical and geometrical relations are simultaneously seen from a single unit or from a short exploration path. In Le Corbusier there is no direct observation of the spatial, physical and geometrical system as a whole.

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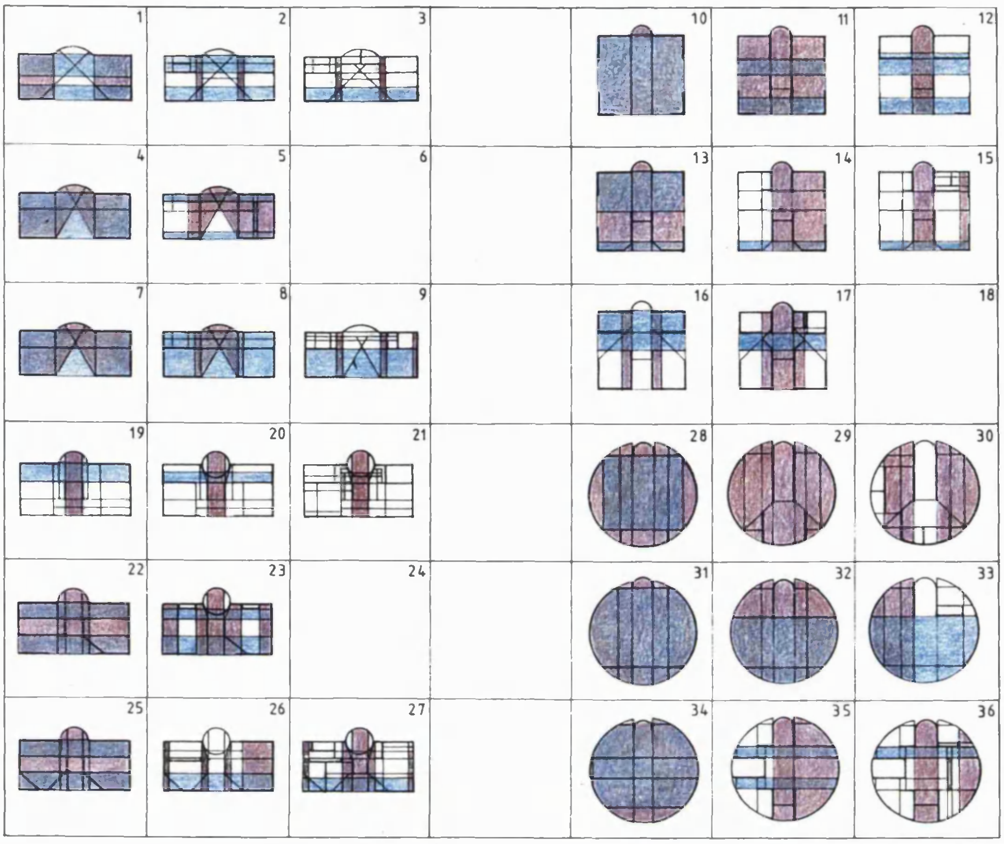
74 There is an exception in Le Corbusier also provided by the first floor of LH3 in which there are very few such units, (TB-L 5.3, fig. 57, p. 413).

75 This is because the central short path unit is situated on the landing.



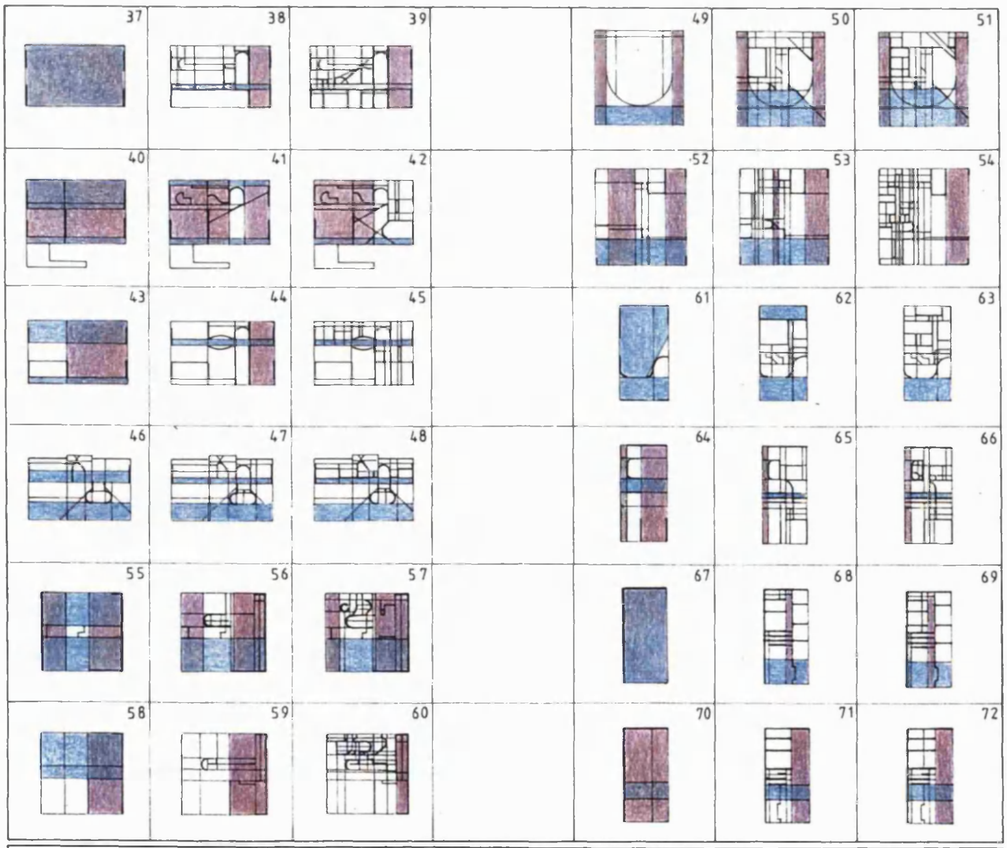




Table B - L 5.1 - GLOBAL SCALE CONVEX SPACES
Comparative examination of Botta & Le Corbusier's houses

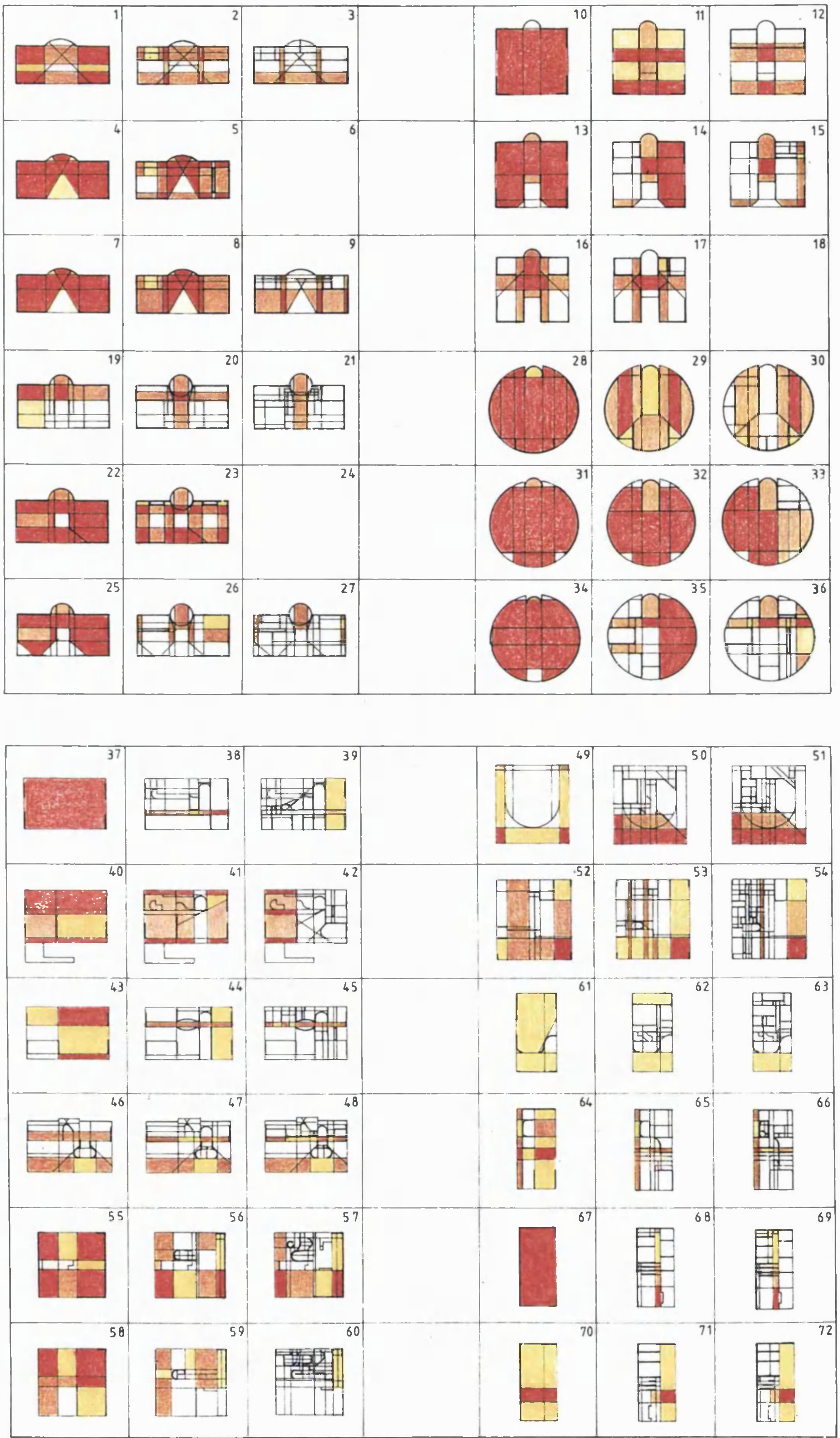
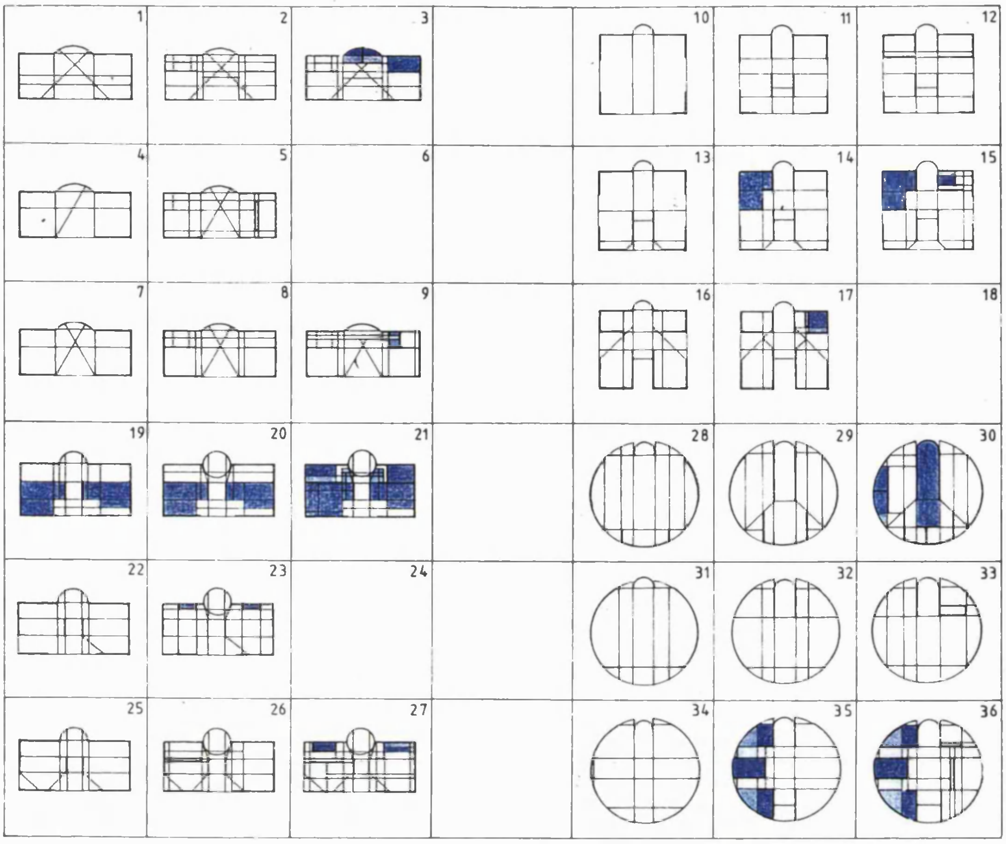


Table **B - L 5.2** - GLOBAL SCALE UNITS
Comparative examination of Botta & Le Corbusier's houses



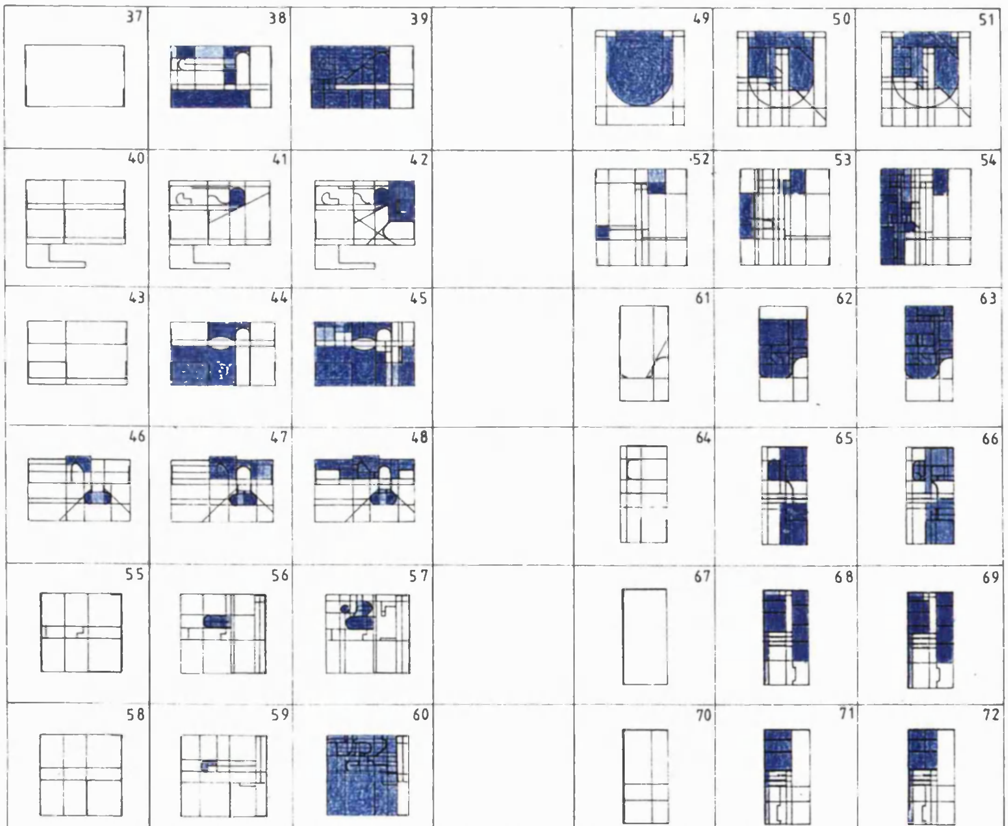


Table B - L 5.3 - LOCAL SCALE CONVEX SPACES NOT OVERLAPPING WITH GLOBAL SCALE CONVEX SPACES
Comparative examination of Botta & Le Corbusier's houses

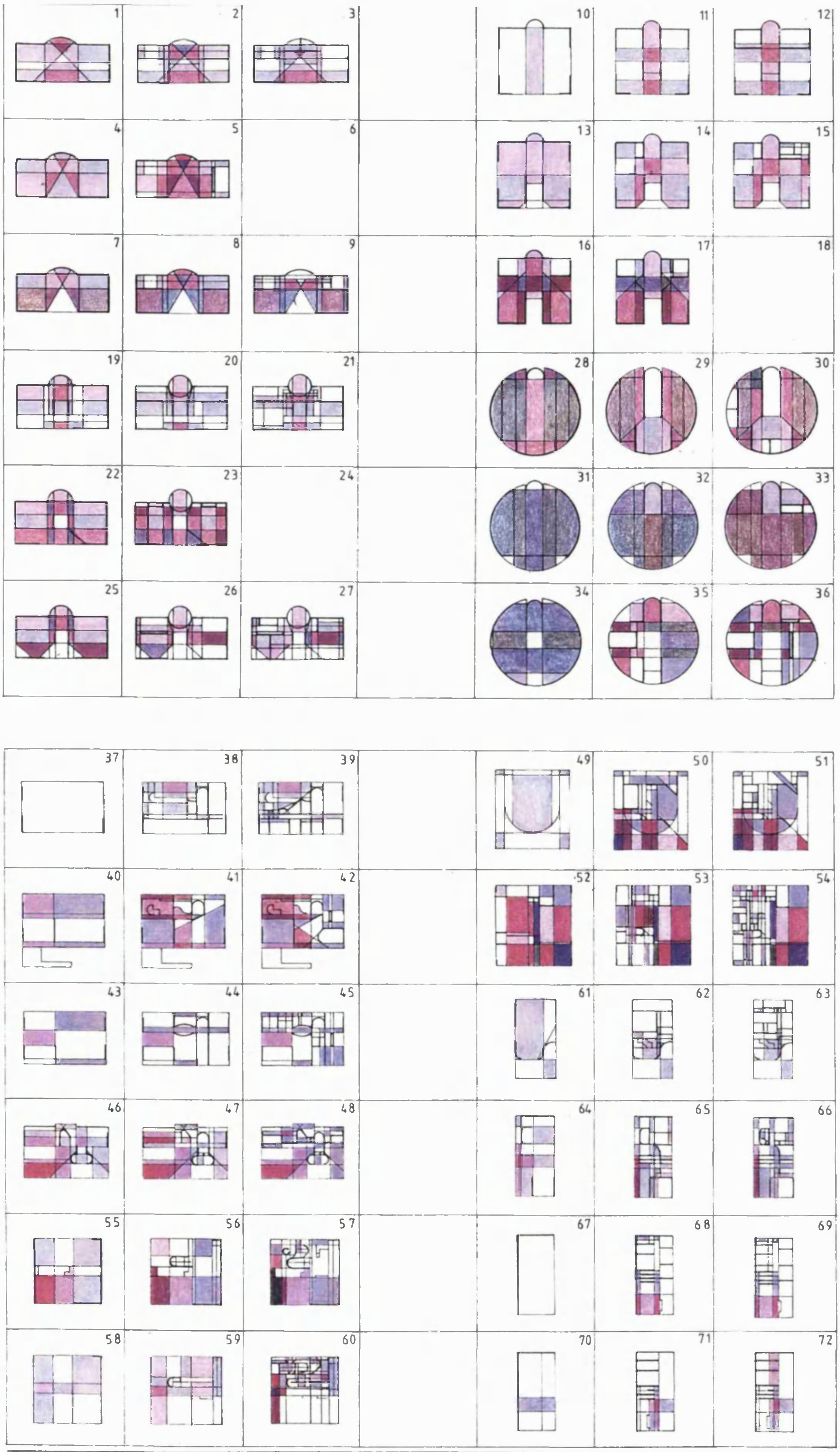



Table B - L 5.4 - OVERLAP UNITS
Comparative examination of Botta & Le Corbusier's houses

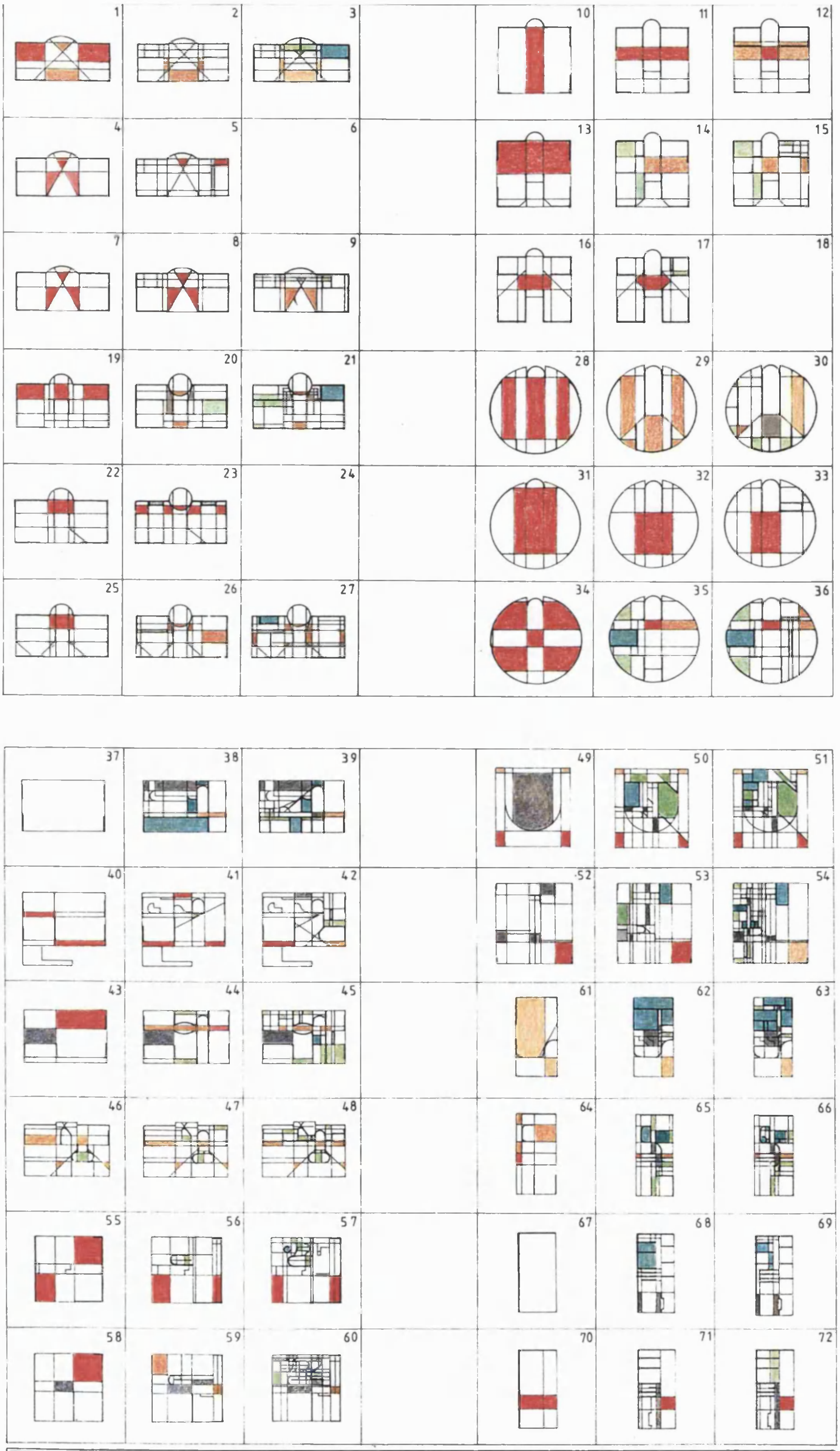



Table B - L 5.5 - SHORT PATH UNITS
Comparative examination of Botta & Le Corbusier's houses

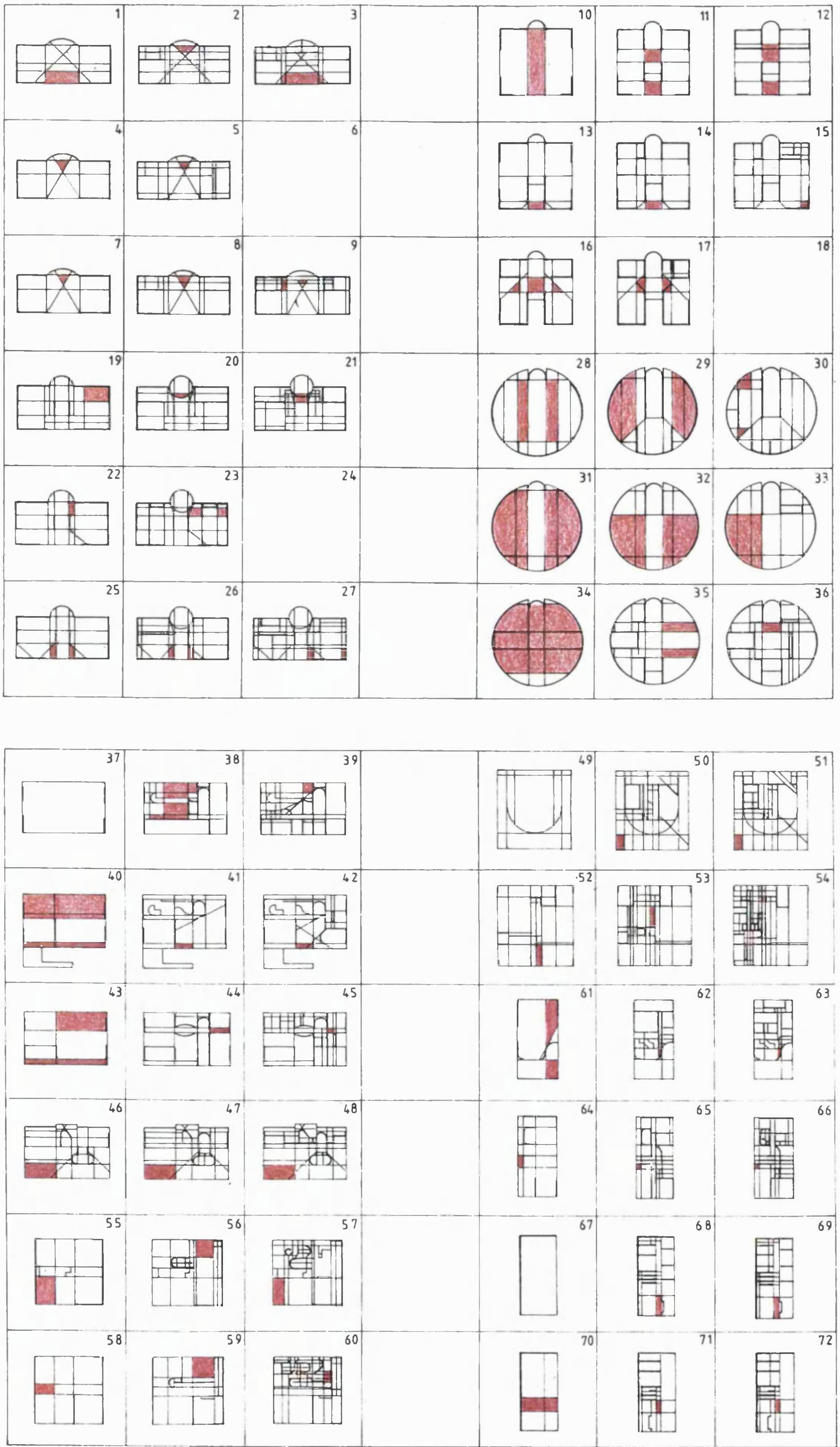



Table **B - L 5.6** - **MOST CONNECTED UNITS**
Comparative examination of Botta & Le Corbusier's houses

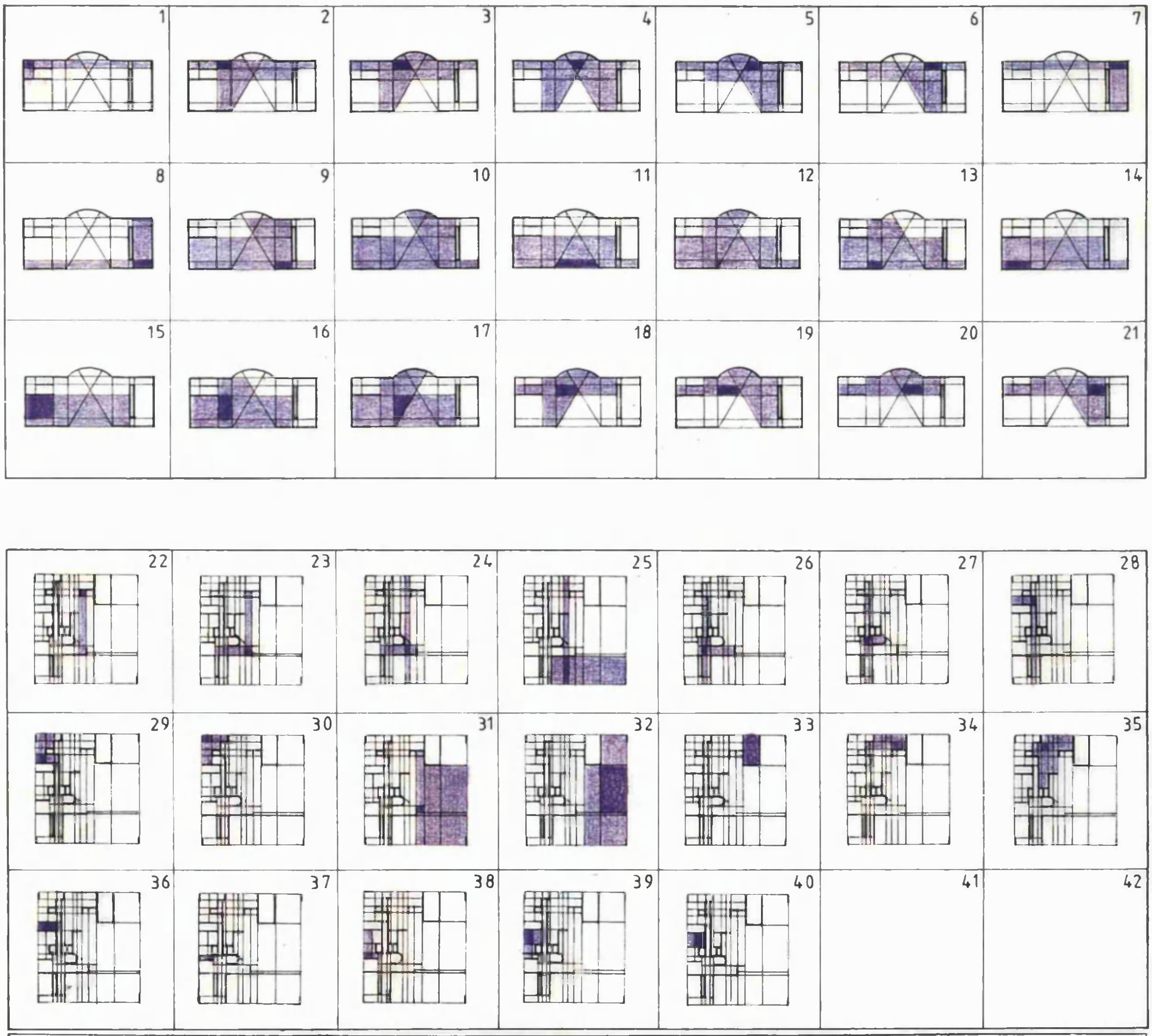



**Table B - L 5.7 - VISUAL FIELDS**
Comparative examination of TBH1 & TLH1

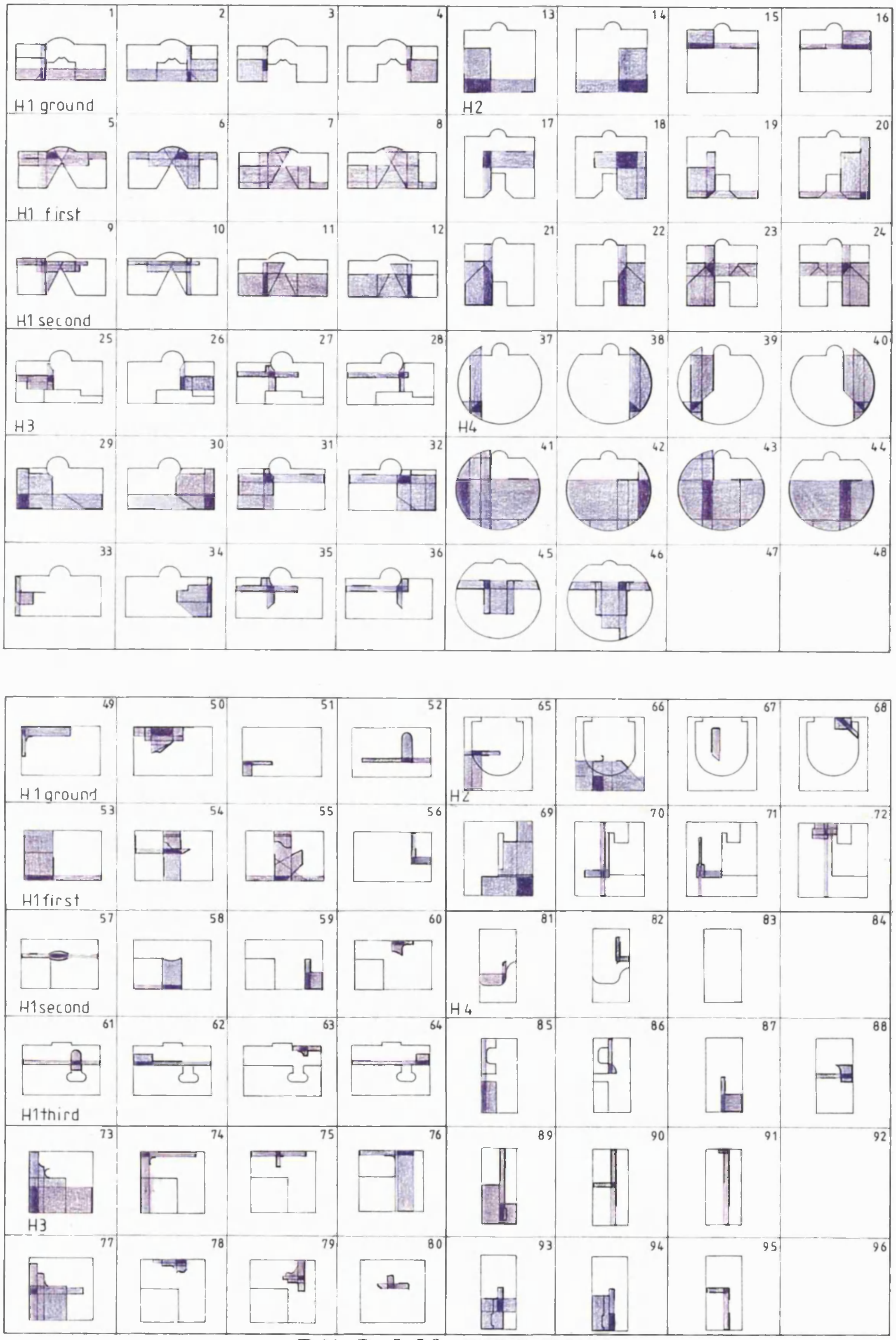



**Table B - L 5.8 - VISUAL FIELDS**
Comparative examination of Botta & Le Corbusier's houses

- The Invariance-Value index in Botta at stage three is over 0.50, (8/12 plans), (TB 5.14, p. 350). This index in Le Corbusier is below 0.30, (8/12 plans) (TL 5.10, p. 390). *In this respect, Botta provides a stronger degree of visual synchronisation of spatial relations from certain positions than Le Corbusier.*

In seven out of twelve of Botta's plans, (7/12), the most connected unit of some of the most connected units are either situated on the BF axis or they are geometrically co-ordinated on this axis, (TB-L 5.6, fig. 5, 9, 12, 16, 21, 36, p. 416). In Le Corbusier there is no geometrical pattern that distributes the most connected units on the plans, (TB-L 5.6, fig. 37-72, p. 416). Thus spatial synchronisation in Botta is offered from a geometrically significant location. In Le Corbusier the units synchronising spatial relations are not geometrically significant.

- **Static-dynamic spatial experience**

The characteristics mentioned above show that in Botta global and local scale information is either concentrated on a single location[76] or constantly distributed to a large number of locations[77]. Besides, the spatial system is revealed from a single or from a number of spatial points constituting an ordered and economical observation route.

There is also a synchronous exposure of global and local scale interconnections of surfaces from a single location and a successive exposure of these interconnections from every location. The outer surfaces enter every visual field integrating global and local scale spatial relations. Finally, global scale geometrical relations amongst close and distant spaces are simultaneously exposed from a single unit or from a short exploration path.

In Le Corbusier global scale information is restricted, the connection between the global and the local scale elements is weaker and local scale information is widely distributed in a large number of positions. The spatial system is also revealed through an extensive and random exploration path.

Besides, global and local scale physical relations are successively synchronised from a limited number of positions. The majority of spatial locations expose only local scale physical relations. Finally, there is no geometrical integration of spatial and physical relations.

It seems that the two architects construct two different kinds of spatial experience. One is based on an immediate or a successive exposure that presents maximum information to an almost *static observer*. The

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76 This is the central short path units and the most connected units.

77 These locations are the Global Scale convex spaces, the Global Scale overlap units and the Global-Local Scale overlap units.

other is based on a delayed and distributed exposure that sequentially reveals small scale information to a *peripatetic observer. The former is a static experience. The latter is a dynamic one.*

The physical and geometrical co-ordination of spatial relations in Botta reinforces the static experience. On the other hand, the lack of integration of distant spatial episode by boundaries and geometrical axes in Le Corbusier accentuates the dynamic experience.

- **Invariant spatial, physical and geometrical properties and spatial experience**

This part of the analysis looks at the layouts in terms of the degree to which invariant characteristics are built into the structure of visual information. Two kinds of invariant characteristics are distinguished. One refers to those characteristics that are observed through a large scale exploration that covers the house as a whole. The other is about characteristics observed from small scale exploration. The former, accounts for invariant properties experienced *across spaces.* The latter accounts for invariant properties experienced *amongst spaces.*

- **Invariant properties across spaces**

The spatial properties across spaces can be summarised in the following:

- In Botta the Global Scale convex spaces, the Global Scale units, the overlap units, the short path units and the most connected units are usually situated on the same positions in every floor and every house. Thus, a visitor will encounter long views that reach throughout the house moving along the front and the side surfaces as well as next to the vertical shaft, (TB-L 5.1, fig. 3, 5, 9, , 15, 17, 23, 27, 33, 36, p. 411). In Le Corbusier the positions of these elements are different from floor to floor and from house to house. *Thus, Botta creates a repetitive pattern of association between certain kinds of visual information and certain locations across the horizontal and the vertical direction. Le Corbusier does not employ such repetition varying the positions of spatial elements.*

- In Botta the visual fields at the living area differ from those at the entry and at the bedroom levels. The former reveal the layout as a whole from a single central unit. The latter reveal the layout from a number of units gathered around the BF axis. Besides, the former are expansive from the majority of the spatial units, (TB-L 5.8 fig. 5-8, 29-32, 41-44, p. 418). The latter are expansive only at the front through the glazed surfaces of the voids, (TB-L 5.8, fig. 5, 7, 17, 18, 21, 25, 29, p. 418). At the back they are either restricted inside the enclosing spaces or tunnelled along the circulation areas running next to the voids, (TB-L 5.8 fig. 9, 10, 19, 20, 22, 23, 24, 27, 30, 31, 32, 42, 43, p. 418).

In Le Corbusier certain visual fields produced in the living area are also more expansive than those produced at the rest of the levels, (TB-L 5.8, fig. 55, 69, 76, p. 418). However, there is no specific position from which the largest part of the first floor is seen. Besides, the areas from which expansive views are offered are different in each case.

*Thus, in Botta there is a repetitive pattern of association between certain kinds of visual exposure, certain floors and certain locations from which this is offered. In Le Corbusier although there is an association between floors and patterns of visual exposure, the locations from which these patterns are constructed are different.*

The repetitive pattern of spatial exposure carries with it a repetitive pattern of physical exposure. Thus, the outer surfaces are seen in full length from the same locations. Besides, there is a repetitive pattern of physical exposure that associates the first floor of most of the houses with a direct exposure of the physical system and the rest of the floors with a successive exposure of this system. On the other hand, in Le Corbusier the positions of the spatial elements offering access to these surfaces are different from one floor and from house to house. Thus, there is no specific pattern in which the interconnections of surfaces are revealed.

Besides, in Botta there are symmetrical or almost symmetrical visual fields produced from distant units that are symmetrically distributed with respect to this axis, (TB-L 5.8, fig. 1-2, 11-12, 21-22, 29-30, 39-40, p. 418). In Le Corbusier there are no symmetrical visual fields, (TB-L 5.8, fig. 49-95, p. 418). Thus, in Botta an observer moving across distant spaces captures a horizontal reflection of visual fields on the BF axis. This shows that the geometrical properties add geometrical invariance into the transformation of visual information.

**Deterministic - probabilistic spatial experience**

In a floor by floor visit of a house of Botta or in a hypothetical visit of all houses an observer encounters a system that looks more and more familiar. Global scale information is always transmitted from the sides and the front of the layout. Local and global scale information interact from the same positions. Besides, the first floor is seen as a whole from the landing, while in some cases the ground and second floors are seen through a short route covering a specific area of the plan. Finally, distant spatial locations offer identical or almost identical visual fields showing that information is repeated along the vertical and the horizontal direction.

Visiting a house of Le Corbusier one sees a system that looks different from different points of view. Global scale information shifts from one side to the other. Local and global scale information interact at different areas. Finally, in each case a complete picture is possible through a different route that is random and spreads throughout the plans.

It seems that in Botta a certain order is built into the transformation of information reassuring that visual fields occur in a specific way. Possible violations of this occurrence take place based on slight variations regarding the locations and the configurations of particular elements[78]. However, the repetitive pattern of information transmission is strong enough to prevail.

In Le Corbusier there is less order characterising the occurrence of visual fields. The probabilities of what will be encountered and in which way are open. This is because the different kinds of visual exposure change locations along horizontal levels and across houses.

The repetitive pattern of information transmission in Botta creates a *repetitive pattern of spatial experience.* The absence of repetition in Le Corbusier creates a *variable pattern of experience.*

Thus, spatial experience in Botta *accommodates very little probability and a great deal of repetition and certainty.* In Le Corbusier *it accommodates very little repetition and a great deal of probability and uncertainty. The former is a* ***deterministic*** *experience. The latter is a* ***probabilistic*** *one.*

The deterministic experience in Botta is reinforced by the structure of movement. There is always a single vertical route through his houses that is controlled by a single staircase. There is also a single horizontal route passing from the landing and branching off in a tree-like manner to the spaces on its either side. *Therefore, there is a single way to move offering no alternatives in the sequences in which spaces are seen.* Repetitive visual fields that are encountered in a specific order make one realise what the layout has to offer, which are the strategic positions and which is the route that makes them accessible.

The probabilistic experience in Le Corbusier is also accentuated by the patterns movement. There are usually two staircases in his houses creating vertical loops. These are often enriched by major or minor horizontal loops. *Thus, there is more that a single way to move in Le Corbusier's layouts. Alternative vertical and horizontal pathways enable a visitor to exercise choice in spatial exploration.* Changing visual fields encountered in a variety of ways leave the interpretations open regarding what will be seen, which are the significant positions and which is the way to move in order to reach them.

**Spatial properties amongst spaces**

The spatial properties amongst spaces can be summarised in the following:

A large number of Global Scale convex spaces in Botta results in *a large number of visual fields that retain constant contact with large scale information and with the outer surfaces for a sequence of steps.* This can be shown by looking at TB-L 5.7, fig. 1-7, (p. 417). Moving from left to right at the back of the first floor plan one constantly sees the Global Scale convex space stretching at length of the layout.

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78 An example of these variation is the Global Scale convex spaces which are not always situated next to both the left and the right sides of the plans

In Le Corbusier there are fewer Global Scale convex spaces showing that *there are fewer visual fields that have this property.*

- An extensive and continuous coverage of Botta's plans by Global Scale overlap units and Global Local Scale overlap units results in *visual fields that retain constant contact with global and local scale information, the inner and the outer surfaces.* Looking at figures 1-21 in TB-L 5.7, (p. 417) it becomes evident that every visual field exposes areas reaching throughout the layout as a whole that are also encountered in a previous step. In Le Corbusier a large number of non overlap units results in *visual fields that access a different convex space and a different set of surfaces at a time.*

- In Botta short path units often belong to the same Global Scale convex space or Local Scale convex space. There is, thus, *constant visual contact with this space as one progresses from one short path unit to the other.* In Le Corbusier short path units belong to different convex spaces resulting in *visual information that changes as one changes his position in space.*

- The high Invariance-Value index in Botta creates *a large number of visual fields that retain constant visual connection with the most connected units.* The low Invariance-Value index in Le Corbusier provides *a small number of fields in which the most connected units feature as invariant constituents.*

- **Continuous-discontinuous spatial experience**

It turns out that global and local scale relations in Botta remain constantly visible for a certain length of time. This can be demonstrated by looking at the visual fields produced from a number of spatial units in the first floor of BH1, (TB-L 5.7, fig. 1-21, p. 417). *Each of these visual fields overlaps with the previous and the next one. Each visual field is connected with the previous and the next one by an area that features in both. Each position offers a fragment of visual information that is encountered before.*

In Le Corbusier's layouts there are areas in which visual fields change gradually retaining constant access to certain portions of space, (TB-L 5.7, fig. 22-26, 27-30, 31-32, 34-35, 37-40, p. 417). However, they have also places from which one looses any contact with a global reference, (TB-L 5.7, fig. 22, 23, 29-36, 37-40, p. 417). Besides, they have areas in which visual fields have nothing in common with each other, (TB-L 5.7, fig. 22, 25, 26, 29, 33, 34, 36, 37, p. 417).

Visual fields produced from a large number of locations in Botta become segments of the visual fields produced from the most connected units. This can be demonstrated by looking at the visual fields produced from the most connected units, (TB-L 5.7, fig. 4, 10, 12, p. 417), and those constructed from the overlap units that are visually linked with the most connected units in the first floor of BH1, (TB-L 5.7, fig. 1-3, 5-9, 11, 13-21, p. 417). The latter always contain a part of visual information featuring in the former.

In Le Corbusier a large number of visual fields are different from those constructed from the most connected units, (TB-L 5.7, fig. 22-34, 35, 36-40, p. 417). They seem to offer no basis for understanding where one can position himself to obtain a visual field that is a summary of the information received from a number of steps.

Overlapping visual fields in Botta produce smooth changes in visual information. In Le Corbusier an alternating pattern of overlapping and disconnected visual fields exposing similar and different parts of the layouts from one step to the other produce smooth and sharp changes in visual information. *It seems that spatial experience In Botta is based on '**continuous change**'. Experience in Le Corbusier is founded on alternating patterns of continuous and '**discontinuous change**'.*

In the previous section it was suggested that there is *repetition experienced across spaces* based on a repetitive pattern of spatial exposure that associates kinds of visual fields with distant locations on the same level as well as in different horizontal levels. This section shows that there is also repetition amongst spaces based on a certain amount of information that is repeated during a sequence of steps that are closely linked to each other.

A geometrical definition of repetition is *translation*, i.e. the displacement of a figure in the plane up, down or sideways. Translation keeps the shape and size of a figure invariant while changing its position. A repetitive pattern of visual fields encountered in each floor shows that there is a vertical translation of visual fields. A repetitive visual contact with a certain segment of space encountered at the same floor shows that there is a horizontal translation of this segment. This means that it repeats itself as the observer moves inside a convex space.

Both kinds of repetition depend on the observer's movement to be picked up. However, the vertical sliding of visual fields are external to the viewer's movement. On the other hand, the horizontal sliding of fields is internal to his movement in the sense that he is the carrier of repetition as he moves along a space[79].

An extensive employment of vertical and horizontal translation of visual fields by Botta show that invariance is built into spatial experience. This is because certain patterns of visual information remain the same as one moves and changes his position in space. In Le Corbusier there is only horizontal translation occurring in specific areas. Therefore, there is less invariance in the patterns of visual information.

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79 Vertical translation registers as a displacement of the visual field along the vertical direction because the two fields are disconnected from each other. Horizontal translation of a convex segment of a visual field registers as a single homogenised visual field rather than as a series of individual visual fields. However, if visual fields are thought as a set of individual frames the existence of translation becomes evident.

### Synchronisation, invariance and their effects in spatial experience

To summarise, analysis identified that the two architects create two different kinds of spatial experience. A large amount of information exposed to an almost static observer, a repetitive pattern of information transmission and visual fields that change smoothly in Botta construct a *static, deterministic and continuous spatial experience.* A delayed spatial exposure, its distribution throughout the layout, a random pattern of information transmission and alternating smooth and sharp changes in visual information in Le Corbusier create a *dynamic, probabilistic and discontinuous spatial experience.*

A static experience is based on a simultaneous and a successive synchronisation of global and local scale relations released from local scale explorations. A dynamic experience is constructed by a synchronisation of local scale relations produced from global scale explorations.

A deterministic and continuous experience is based on global and local scale characteristics that stay invariant as the observer moves and changes his position in space. A probabilistic and discontinuous spatial experience is based on local scale characteristics that stay invariant in the transformation of visual information.

*It turns out that synchronisation and invariance in Botta characterise global scale relations. In Le Corbusier they operate at the local level.*

## SPATIAL EXPERIENCE AND COGNITION

The discussion at this point comes to the question set at the beginning of the examination of spatial properties: *How the spatial, physical and geometrical characteristics mentioned so far and the kinds of spatial experience they create induce the observer to perform a set of operations that lead to the grasping of the spatial system?*

### Static - dynamic spatial experience and cognition

A static experience in Botta draws the viewer into a *direct observation* of global scale spatial, physical and geometrical relations. *Properties observed at once lead a viewer to grasp the layout at once.* A dynamic experience in Le Corbusier draws an observer into a *gradual observation* of local scale relations. *Spatial properties observed gradually lead to a gradual grasping of the layout.*

In the former cognition is immediate. In the latter it evolves through time. In the former the mental operations cease to be at work after everything is taken at once and the process of inquiry closes down as soon as a single reading is reached. In the latter these operations are constantly at work as a series of readings are constructed following the sequential experience of space.

In the previous chapter it was proposed that Botta's plans facilitate an understanding of space from its two dimensional representation. The simple relations among spaces and boundaries suggested that the experience of the actual space leads also to an immediate grasping. Analysis of Le Corbusier's plans suggested that an observer finds difficult to read the organisation of space by looking at its representation. The multiple and complex interconnections between fragmented shapes, boundaries and grids seem to suggest that from the interior the houses also present themselves as series of multiple and disconnected spatial events.

*This analysis reaffirms these hypotheses showing that intelligibility of actual space in Botta is immediate and founded on a static appreciation of the layout from a single or from a limited number of positions. On the other hand, intelligibility in Le Corbusier is sequentially built based on a dynamic appreciation that is widely distributed throughout the layout.*

In this respect, it is not only the multiple readings amongst the volumes and shapes identified in the previous chapters that establish the connection of Cubist painting to Corbusian buildings. It is not only the spatial recession of the implied vertical planes identified by Colin Rowe either. It is also actual space. Willing to grasp a house one has to direct his attention to the ways he can put together the discontinuous, ever changing and intricate fabric of events encountered in every step.

Similarly to the cubist paintings in which fragmentation seeks the viewer's active participation in the depiction of a total scene, the disconnected spatial episodes in Le Corbusier's houses *remind the viewer that he has to engage, participate and actively synthesise the total condition of space.*

Intelligibility in Le Corbusier is based on a *cognitive synthesis demanded from the viewer.* Intelligibility in Botta is based *on a visual synthesis offered to the viewer.* However, regardless of how much exposed Botta's layouts are, there are certain locations that are not directly visible. Besides, although the ground and the second floor are seen through an ordered exploration path, although visual fields along this paths look similar, they are often disconnected from each other. Therefore, a cognitive synthesis is required in Botta's houses also. The question to ask next is: *How this synthesis is achieved in the houses of both architects and which are the operations that shape it?*

### Deterministic - probabilistic, Continuous - discontinuous spatial experience and cognition

Similar visual fields from different points of view in Botta's houses result in a system that looks more and more familiar. The repetitive pattern of information gradually generates a certain knowledge about the layout and the house as a whole. Sooner or later an observer realises which are the positions he has to occupy to see most and which are the positions he can omit to avoid repetition.

Visiting a house of Le Corbusier one sees a system that looks different from different positions. In this way, it is not possible to know what the layout looks like prior to exploration. Knowledge remains probable as the next space, floor and house is seen.

The repetitive characteristics encountered during spatial experience give guidance for what comes next. In Botta the visitor realises that a few steps forward possibly contain unknown information. However, he also realises that these steps lie within a spatial segment he knows already having encountered it for a certain time. In Le Corbusier forward readings are possible from the areas of 'continuous change'. From those where new knowledge is added in every step there is very little projection of what is already known to what is hidden and comes next.

Therefore, a deterministic and continuous spatial experience in Botta enables the observer to pick up structural characteristics about the layout as a whole from the invariant characteristics he observes locally. *There is a kind of forward walking that enables the viewer to form assumptions about the global system based on what is experienced at the local level.*

A probabilistic and discontinuous spatial experience in Le Corbusier does not lead to a single interpretation about the layout as a whole from local scale information. Facing a changing pattern of information transmission one can extrapolate a variety of possible interpretations. A final one is formed only when *all different visual fields are tried and comparative knowledge of these fields is achieved.*

Thus, Botta *cues the viewer* to anticipate in advance what visual fields offer and from which position. These anticipations are constantly validated closing down the probable hypotheses and leading to a final interpretation. *Cognition develops according to a closed and predictable sequence of mental operations based on confirmed hypotheses.*

Le Corbusier challenges the viewer's assumptions and inferences by a changing pattern of information transmission. Hypotheses are more open in the sense that there are many alternatives in the ways in which information is revealed. Fulfilled predictions generate forward readings. Unfulfilled ones make a viewer to readjust his expectations. Inferences are constantly validated, suspended or left open. *Cognition develops according to an open and unpredictable sequence of mental operations based on confirmed and disconfirmed hypotheses.*

However, the comparative examination of the houses of Botta suggested that in his layouts deviations from the overall pattern introduce some variety and differentiation. For example there is no absolute symmetry realised everywhere. Besides, some plans like the first floor of BH1 expose their right surface in full length but break the continuity of the left surface challenging a possible anticipation of a uninterrupted extension of the outer boundary in both sides, (TB-L fig. 1-21). It has been argued that these breaks attract attention to both global and local patterns which otherwise would fail to register due to continuous repetition. It can be also argued that they become details to linger over, exceptions to focus on adding some discovery and surprise to the habitual pattern of moving and grasping the layouts.

- **The notions of synchronisation and invariance and their effects in cognition**

It was suggested that synchronisation and invariance in Botta characterise global and local scale relations. Synchronisation leads the observer to grasp the system based on a direct exposure of global and local properties. Invariance leads the observer to undergo a predictable and closed process of hypotheses based on a constant pattern of occurrence of global and local scale relations.

On the other hand, synchronisation of small scale characteristics in Le Corbusier delays and distributes spatial exposure throughout the layout. Invariant local characteristics generate a set of open probabilities that are subjected to constant modifications during the observer's search for spatial coherence.

In Botta expectations that are quickly and constantly proved correct lead a viewer to select or skip positions and shorten his exploration route. The exposure of the first floor from a single position acts as a crucial point for the confirming of a hypothesis. In Le Corbusier spatial exposure unwinds in time so that fulfilment of expectations is considerably delayed. Positions cannot be skipped as one is rarely certain about non visited areas.

Therefore, synchronisation and invariance lead also to redundancy, i.e. to visual information that does not convey any additional information. An observer does not have to wander about Botta' s' houses in his effort to understand. On the contrary, his exploration pathways would seem to become shorter and shorter. These pathways are determined by a circulation system that provides a single way to move leading directly to the most prominent positions. Following a closed system of inferences supported by the circulation system he would seem to emerge soon after his exploration started proceeding to the next floor.

The observation route in Le Corbusier cannot be shortened as there are areas in which new information constantly enters the field of vision. Driven by his challenged predictions the observer would seem to extend his exploration. Encouraged by the alternative circulation pathways he would seem to see the system many times checking and approaching spaces from multiple points of view.

Thus, Botta invites an observer to take *inferential walks*[80] outside space and use his mental operations to find his way. In other words, he enables him to speed up and use these inferences to understand actual space. Le Corbusier also invites his viewer to take inferential walks. However, he suspends the mental

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80 U Eco uses this term to describe the ways a reader formulates hypotheses in the fictional narrative. U Eco 'The Role of the Reader' Bloominghton: Indiana University Press, p. 31-33.

operations requiring him to slow down and take a number of possible *actual walks* in the sequential medium of space.

Thus, synchronisation and invariance of global and local scale relations in Botta create an ordered pattern of information transmission subjecting the sequential medium of space into mental operations. Learning the spatial system by moving about and scanning the actual material of space is to a great extent substituted by inferential processes. On the other hand, synchronisation and invariance of small scale relations in Le Corbusier create a less ordered pattern of information transmission. Mental processes cannot supersede the sequential medium of space developing parallel to spatial exploration.

According to Gombrich repetitive visual patterns fail to register after a time[81]. The same characteristics repeated in every house and in every floor would make one to pick up strategic points in Botta's layouts almost automatically. In a hypothetical visit of all his houses the process of retrieval would be more and more automatic and the wandering about the layouts less and less experimental.

On the other hand, an information system that constantly changes demands an active engagement and participation. The withholding of knowledge, the delays in satisfying an expectation and the surprises arising from unfulfilled expectations in Le Corbusier would seem to arouse the viewer's keener interest and attention.

In Botta the development of mental operations that explain the ways spaces are held together from distance shows that attention is directed from the sequential unravelling of space to the ordered pattern that organises space synchronously. *In other words, Botta seems to enable the viewer to direct and organise his spatial experience by formal properties.*

Le Corbusier prolonging sequential experience attracts the viewer's attention to this experience. At the same time constructing a delayed access to a final interpretation about how the spatial sequences relate at the global level he arouses his keener interest in this interpretation. In other words, sequential and synchronous experience operate as two opposing poles constantly demanding interest for themselves. *It seems that space systematically breaks and delays the viewer's access to the properties of form arousing his keener interest in the ways it is put together.*

At this point the discussion comes to the second question posed at the beginning of this section. How a viewer grasps the mechanisms that hold the sequences of spaces experienced serially together? How the buildings cue the observer to grasp the ways the spatial episodes extend beyond their positions in these sequences to be linked together into a coherent whole? How the sequential medium of space solicits understanding of the synchronous plane of form?

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1 E. H. Gombrich, 'The Sense of Order', Phaidon Press, 1992.

A hypothesis formulated above suggests that Botta gives direct access to the formal properties. On the other hand, Le Corbusier obstructs, suspends and prolongs this access. At this stage analysis attempts an examination of the relationship between the two levels of properties with a view to answer these questions and test this hypothesis.

- **THE RELATIONSHIP BETWEEN THE SPATIAL AND THE FORMAL PROPERTIES**

- **Physical properties of spatial articulation and physical properties of formal articulation**

Analysis showed that Botta's houses construct a simultaneous access to a large part of the outer boundary, the surfaces of the void and the inner surfaces and a constant successive access to these elements. It also showed that the outer surfaces enter every visual field synchronising global and local scale spatial and physical relations. This means that the outer surfaces assume an integrating role binding distant and close spaces together. *In this respect, the physical structure of space is based on a hierarchical distinction of the outer surfaces from the rest of the surfaces in the layouts.*

Volumetric Analysis and Plan Analysis suggested that the physical organisation of the formal properties in Botta's houses is subjected to the rules governing the largest volumetric component. It was argued that a hierarchical application of rules from the largest to the smaller scale retains a hierarchical distinction of the block from the rest of the components. In this respect, *there is an association between the physical properties of spatial organisation and the physical properties of the formal organisation.*

It turns out that the invariant physical characteristics picked up during spatial experience are the ones organising the formal structure. *Thus, the association between the two levels of properties brings this structure directly into the level of spatial experience.* The direct and successive observation of global scale physical and spatial relations lead the viewer to grasp how the surfaces group themselves into smaller categories of voids and interior volumes brought together under the co-ordinating role of a higher category, i.e. the outer boundary.

Besides, the void and the staircase volumes reaching throughout the height of each house extend the horizontal synchronisation of the above elements into the vertical direction. A horizontal and vertical integration of elements groups them into a single system incorporated within a physically identifiable periphery. The volumetric modelling of the house as a whole becomes, thus, graspable during spatial experience.

In Le Corbusier there is no simultaneous synchronisation of global and local scale physical and spatial relations. Besides, a successive synchronisation of these relations is limited in a specific area of the plans, the outside and a part of the inside space. The largest part of the layout reveals only small scale interconnections amongst the outer and the inner surfaces. Thus, certain outer surfaces integrate global and local scale relations constructing an hierarchical distinction amongst the rest of the surfaces and themselves. *However, this is not evident elsewhere and the hierarchy is decomposed into a network of physical elements the interconnections of which remain hidden.*

Volumetric and Plan Analysis suggested that a lack of systematic preservation of physical properties decomposes the volumes of both the three dimensional and the two dimensional articulation into an interaction of volumetric and planar components. This decomposition operates against the hierarchical distinction of the block from the rest of the elements. This analysis suggest that a lack of systematic preservation of physical properties decomposes the physical system of spatial articulation into a network of disconnected surfaces. Thus, it does not preserve a hierarchical distinction amongst the outer and the inner surfaces either.

In this respect, the two levels of properties are organised according to the same principles. However, at the level of the external appearance of the houses an implicit physical definition of the largest volumetric component is retained[82]. Although the decomposition of the volume generates volumetric and planar readings, this implicit definition constructs an awareness of its physical identity as a single volumetric component. At the level of the plan the outer boundary is also analysed into solid and transparent planes. However, at the two dimensional level its identity to be a binding element that surrounds the rest of the inner surfaces is observed at once.

At the level of the sequential medium of space though, there is only partial evidence of a periphery that binds relations fro distance. An observer cannot easily understand how the rest of the surfaces group themselves synchronously into categories of spatial volumes either. *Therefore, the physical properties of the spatial structure does not seem to aid to the appreciation of the formal system.*

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82 This is based on a planar extension of one of the surfaces of the excavated volume. The extended surface restores the physical definition of one of the sides of the block providing also an implicit physical definition of the missing vertex.

- **Geometrical properties of spatial organisation and geometrical properties of formal organisation**

Analysis of the geometrical properties of spatial organisation suggested that the distribution of spatial elements in Botta is governed by 'just about' symmetry or local symmetry.

Volumetric Analysis concluded that the shape and the grid geometrical ordering of each horizontal level as well as of the houses as wholes is governed by overall symmetry on the BF axis. Plan Analysis also observed that the shape and the grid geometrical ordering of the layouts is governed by overall symmetry, 'just about' symmetry, or local symmetry throughout the stages, (TB 4.1 Symmetry Shape index, BF, p. 258, TB 4.2 Symmetry Grid index, BF, p. 258). *Therefore, the geometrical properties of the spatial articulation either coincide or are close approximations of the geometrical properties of the formal articulation.*

Therefore, the invariant geometrical characteristics observed during spatial experience are the invariant geometrical characteristics of the formal structure. In other words, the association or close approximation between the geometrical properties of the spatial organisation and the geometrical properties of the formal organisations brings *the latter into the level of spatial experience.*

Geometrical regularity co-ordinates large scale spatial and physical relations seen at once as well as large and small scale relations seen successively. An observer seeing symmetrical portions of surfaces and spaces from adjacent and from distant areas can grasp how these elements group themselves into larger and smaller categories of geometrical shapes and geometrical lines under the co-ordinating role of BF axis. *Therefore, the geometrical properties of spatial organisation integrate distant and close spaces and surfaces together under the organising role of the BF axis aiding to the intelligibility of the formal system.*

Coming to Le Corbusier analysis showed that there is no symmetry organising the disposition of the spatial elements. Volumetric and Plan Analysis suggested that there is no overall shape symmetry characterising the organisation of the volume and the plan in any stage. The only exception is the ground and the first floor of LH3 which are governed by shape symmetry on the diagonal axis, (TLH3 3.2, fig. 7, 14, p. 200). Thus, in these cases the asymmetrical organisation of the spatial structure contrasts the symmetrical organisation of the external articulation.

The analysis of the grid organisation of the volumes pointed out that there is overall symmetry characterising the grid organisation of the volume as a whole in LH1, LH2 and LH4[83], (TLH1 3.3, fig. 30, p. 197, TLH2 3.2, fig. 24, p. 198, TLH4 3.2, fig. 29, p. 201). Thus, the symmetrical organisation of the grid structure of the volume as a whole contradicts the asymmetrical organisation of spatial

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83 This was found in the superimposition of the physical grids of all floor plans in LH1, LH2 and the superimposition of the physical grids of all floors with the structural grid in LH4.

structure. Therefore, there is not a single geometrical rule governing the external articulation of the houses and the spatial articulation of their interiors.

The analysis of the grids of each plan suggested that there is no consistent pattern of symmetry development. In this way, analysis demonstrated that there is no specific emphasis on a regular disposition of the geometrical bays. However, there are cases in which the grids are symmetrical or 'just about' symmetrical on the BF or the LR axis. More particularly, seven out of twelve plans, (7/12), at stage one are characterised by overall symmetry or 'just about' symmetry on the BF axis. At stages two and three six and five out of twelve plans are governed by 'just about' symmetry respectively, (TL 4.1 Symmetry Grid index, p. 291).

Therefore, a contrast between a symmetrical or 'just about' symmetrical grid and an asymmetrical spatial articulation is constructed. This shows that there is a specific tendency to dissociate the former from the latter. *In other words, the geometrical properties of the three dimensional and two dimensional formal structure and those of the spatial structure develop in different directions.*

*This dissociation between the two levels of structure shows that the geometrical properties of the formal organisation cannot be observed during spatial experience.* There is no symmetry or repetition in the patterns of visual fields that can enable these fields to group themselves into a geometrical formula. *Thus, there is no way one can grasp the formal system relying on the geometrical relations of the spatial system.*

In the previous two chapters it was suggested that the principle of the free plan is not simply about a dissociation of the walls from the geometrical grid but also about a dissociation between an asymmetrical shape organisation and a symmetrical grid organisation. This analysis extends this observation suggesting that this principle is also about a dissociation of the spatial organisation from the formal organisation. Thus, a richer definition of the free plan is proposed that looks at the underlying principles of different layers of properties suggesting that there are different rules organising each of them.

It turns out that Botta employing synchronisation and invariance of global and local scale spatial, physical and geometrical relations exposes the formal properties of organisation. Le Corbusier constructing synchronisation and invariance of local scale relations disturbs access to these properties.

Thus, the hypothesis formed at chapter two is reaffirmed: *It is through a preservation of invariant characteristics observed during spatial experience that the formal properties are raised into the level of observable properties.*

*This analysis also shows that it is the preservation of spatial, physical and geometrical characteristics in the transformation of spatial articulation that brings the formal properties into the level of observable* *properties. On the other hand, it is a lack of systematic preservation that keeps the formal properties away from being easily detected.*

In the previous chapter it was suggested that synchronisation is extensively employed in Cubism through overlapping planes that convey the condition of depth. Overlap is also seen as contributing to the perceptual synthesis of the whole. At this point it becomes apparent that it is only Le Corbusier's facades or plans that bare a relation to Cubism. In a painting, in a facade or in a plan no matter how fragmented the pictorial scene is, it is seen at once. The spatial medium generally resists simultaneity. Le Corbusier's architectural space accentuates this resistance further. Thus, the analogy of his space to cubism would seem to operate only at the level of the mental operations it sets at work to understand the whole than at the level of certain formal and spatial resemblances.

On the other hand, simultaneity in Botta seems closer to cubism in the sense that it reinforces a totality out of overlapping relations between spatial episodes. However, whereas cubism aims at pointing at the paradoxes of being aware of multiple points of view while experiencing a synchronising medium, the flat surface, Botta aims at pointing at the paradoxes of being aware of multiple points of view while experiencing a sequential medium. Thus, *Botta challenges the norm of space to be experienced gradually composed of different episodes. Le Corbusier challenges the norm of form to guide architectural experience.*

- **The architect and the viewer as composing and cognitive agencies**

At this point it becomes evident that an observer exploring Botta's houses is constantly encouraged to identify a three dimensional and two dimensional physical and geometrical modelling that will organise his spatial experience.

On the other hand, in Le Corbusier's houses the spatial and formal ordering relate in a way that very few intersections are visible. The surfaces of the block that extend uninterruptedly mark these intersections. At these points one becomes aware of the architect as the composing entity who on the one hand conceals his strategies, while on the other encourages the viewer to reconstruct the formal structure of the serial events.

*Thus, it turns out that the ways in which the two architects treat the serial and the synchronous organisation of space aim at building up the viewer's curiosity and draw his attention to the formal mechanisms of construction.*

However, in Botta attention is quickly consumed by the direct exposure of these mechanisms. In Le Corbusier attention is prolonged by their systematic burial. In the former the viewer might loose interest in both serial exploration and synchronous appreciation since he sees everything. In the latter he seems to be constantly engaged in both sequential experience and in the intellectual connections that link his experiences together.

Botta seems to satisfy the viewer's curiosity through a short observation. Le Corbusier seems to arouse the viewer's curiosity through a prolonged observation. Botta seems to suggest that a single viewing is enough. Le Corbusier seems to encourage the viewer to move extensively in a variety of ways and see the building many times and through different points of view.

Therefore, both architects create certain types of viewers. Both create a viewer that focuses on how they want him to see the building and how they direct and stage his spatial experience. However, Botta's viewer realises that what the architect wants him to understand *lies on the close connection between the two levels of properties*. This connection leads to a single interpretation summarised by the vertical sculpturing of a simple volume along the BF axis.

Le Corbusier's viewer remains unable to connect all levels of properties under a single reading of this kind. Encouraged to build up his curiosity he realises that what the architect points at *lies in between the multiple, interwoven and colliding levels of properties rather than on their missing connection.* It lies not on the ability to stand at a single point and extrapolate the global from the local, form from space, but on the intersecting network of interpretations constantly reaffirming and suspending an intersecting network of hypotheses.

In other words, Botta composes addressing his buildings to *a viewer that wants to know how space and form reveal their multiplicity of interconnections.* Le Corbusier composes addressing his buildings to a viewer that *uses space and form as stimuli for a multiplicity of interpretations.*

Arising a certain response to their viewers both architects become also noticeable entities through their controlling and constructive powers which stage the experience and cognition of the serial and the synchronous planes. The viewer's road to access Botta is explicit passing *through the constructive mechanisms of spatial and formal coherence.* The viewer's road to Le Corbusier is implicit passing *through the mechanisms that set coherence in suspension. In other words, the architect and the viewer are complementary entities that become clear to each other in the process of composing and in the process of seeing.*

- **SUMMARY AND CONCLUSIONS**

In this section the discussion returns to the compositional logic the two architects employ in the articulation of space. The aim is examine how this logic affects the different ways in which their houses become intelligible during spatial experience. This inquiry extends also into the compositional logic characterising the formal articulation. In this way, the results of this analysis can be compared to those of the previous chapter leading to an overall examination of the design process and its basic principles. They also lead to an examination of the ways this process influences the ways the formal properties are retrieved during spatial experience.

- **MARIO BOTTA**

Analysis suggested that the transformation of spatial organisation in Botta presents the following characteristics:

- A consistent preservation of spatial, physical and geometrical properties of the first stage.
- A constant association between stages, patterns of spatial articulation and distribution of elements on specific locations.
- A simultaneous and a successive synchronisation of global and local scale relations.
- An invariant participation of global and local scale relations into a large number of visual fields.
- An integration of large and small scale spatial relations by the outer boundary and the BF axis.

Therefore, there is a specific design logic that makes transformations, the patterns of exposure of spatial, physical and geometrical relations and the locations of these patterns specific to each stage. The association between stages, visual patterns and locations and the preservation of the spatial, physical and geometrical properties of the first stage show that design follows a specific course. This course operates according to pre-existing rules of articulation that guide the space in process towards the realisation of a pre-conceived idea.

The same patterns of preservation were found to operate in the transformation of the three dimensional and the two dimensional formal articulation of the houses. Volumetric and Plan Analysis suggested that in each stage rules are specified in order to satisfy the hierarchical distinction between the largest volumetric component and the rest of the elements. Therefore, the preservation of the spatial, physical and geometrical characteristics identified by Spatial Analysis is about a preservation of the formal properties of the abstract generic state. *This shows that formal properties guide the design process from the generic to the specific state, from the arrangement of volumes and shapes on a plan to the arrangement of spatial sequences of the interior articulation.*

- **LE CORBUSIER**

Spatial transformation in Le Corbusier is characterised by the following properties:

- A combination of a preservative and an obliterative mode of transformation. However, the second one is more prevalent allowing properties to move away from the properties of the first stage.
- An association between stages, patterns of exposure and distribution of certain elements on the plans. Nevertheless, there are general locations these elements occupy rather than specific ones. Besides, a large number of elements are randomly distributed on the layouts. Random distribution or distribution of components to locations that are different allow for variation and differentiation amongst floors and amongst houses.
- A simultaneous and a successive synchronisation of local relations.
- An invariant participation of local characteristics into a small number of visual fields.
- A lack of integration of large scale relations by the outer surfaces and the BF axis.

The transformation process constantly constructs associations and differentiations between each stage and stage one. Therefore, there is a specific design logic which on the one hand controls the space in process by a higher level concept, while on the other allows it to develop independently of this concept.

The same observations were put forward in the examination of the formal properties of the volumetric and the plan articulation. Analysis proposed that the subordination of elements to the properties of the block is constantly broken and re-enacted. Therefore, the transformation of spatial articulation is guided by formal properties as well as it breaks away from them. The spatial sequences of the interior seem to maintain a connection with the abstract generic state of form. However, the prevalence of the obliterative mode is such that the synchronous and the serial experience of space develop in separate directions.

It turns out that both architects employ a consistent compositional logic governing both levels of properties, the physical and geometrical properties of three dimensional and two dimensional formal organisation and the spatial, physical and geometrical properties of the spatial organisation. However, Botta's logic subjects the articulation of both levels to the properties of the abstract generic state. Le Corbusier's logic employs two lines of development. One controls formal and spatial articulation by the requirements of the highest formal concept. The other suspends these requirements and frees the form and space in process from their limitations.

*It could be suggested that Botta's design process satisfying knowledge of a pre-existing formal concept is a deterministic process. On the other hand, Le Corbusier's process incorporating unknown possibilities that develop at the latest stages of design is a probabilistic process.*

In this context, analysis concluded that it is a preservation of spatial, physical and geometrical characteristics which constructs a synchronisation of global and local scale relations and invariant global and local scale characteristics observed during spatial experience. On the other hand, a lack of systematic preservation incorporates synchronisation of local properties and local invariant characteristics into the structure of visual information.

In the former spatial experience is subjected to an ordered pattern of visual information that transcends the sequential medium of space. This ordered pattern in Botta allows spaces to jump out of their position in the spatial sequence and become grasped synchronously. Botta cues the observer through a predictable set of inferences to reach a single interpretation and grasp the mechanism of his construction, the synchronous plane of form.

Le Corbusier offering his viewers an open and probable set of inferences draws them into a sequential experience in which mental operations do not point at a single interpretation. He breaks the connection between the two levels of properties delaying the viewer's access to formal and spatial coherence through a set of probable hypotheses. The confirmed and disconfirmed hypotheses, the mental effort required and the surprises arising out of challenged inferences show that he constantly demands and suspends the viewer's access to the formal mechanisms of construction.

A design process governed by a preservative mode of formal properties leads to the maintenance of a simple figurative concept encoded with a simple geometrical and physical description, i.e. the block and its axis of symmetry. This process leads to a spatial experience that is not only guided by this concept but is also subordinated to it. This substitution aims at drawing the observer's attention to the synchronous plane of form.

On the other hand, a design process governed by both a preservative and an obliterative mode allows the figurative concepts and their geometrical descriptions to develop towards more unknown probable directions. Spatial experience unfolds in a similar way based on a set of probabilities that set space and form in constant tension.

*In this respect, design process and experiential process become intrinsically linked. The modes governing the one determine the other. As it was suggested before, the architect and the viewer become complementary entities creating each other in the process of composition and in the process of spatial experience. Thus, the road to spatial and formal description and intelligibility passes through a description of composition as a transformation process.*

Botta bringing all levels of properties under a single rule constantly absorbs and directs the viewers' attention to this rule as the main device of construction that governs and guides his spatial experience. Le Corbusier allowing the two levels to be interrelated as well as differentiated makes the viewer's attention to oscillate from the one to the other.

From the outside Botta's buildings look simple. The viewer grasps the symmetrical sculpturing of a single and physically coherent volume. His first hypothesis would seem to be about a symmetrical and single spatial enclosure. The plan defined by a clear peripheral line and organised along the BF axis validates the hypothesis.

Moving to the ground floor he might loose the oneness of the outer boundary but he observes symmetrical and continuous portions of this boundary. The initial hypothesis seems still valid. The symmetrical expansion of the visual fields at the first floor and the continuous periphery reassures his expectation. The second floor is seen also serially. Nevertheless, horizontal and vertical views through the void are still present and the visual fields keep repeating themselves horizontally and vertically while surfaces unfold connecting his spatial steps together.

Exterior and interior connect together under a single reading. There might be moments the viewer decides to linger over the small incidents that deviate from the overall pattern. Nevertheless, there is not much he has not seen or he has not understand. Leaving the building he might realise that discoveries are exhausted. A multiplicity of relations brought together under a single organising rule is the outcome of the exploration. The architect has spoken clearly through a discursive surface of space.

Looking at Le Corbusier's buildings the viewer is perplexed. The decomposed volumes defy a single interpretation. However, the physical implicitness of the block makes him to lock his attention on it and proceed to find evidence of its priority elsewhere. Looking at the plan the fragmentation of the spatial volumes continues to puzzle. Nevertheless, the surrounding periphery is a visible fact. A scrutiny of both the plan and the volume reveals the underlying presence of grids providing some further evidence of construction.

Entering the building this evidence can be seen in the binding outer surfaces that synchronise the inside and the outside spaces. Nevertheless, elsewhere is lost diffused and hidden behind the twisting surfaces. Alternating pathways bring him again to the moments of expansion where the evidence of the exterior is recovered. However, the grid lines are absent, the outer boundary is fragmented and a plethora of small incidents absorb attention by their sculptural qualities and their unexpected appearance.

Perplexed by his attention that focuses on contradicting and never resolved directions the viewer might attempt a number of journeys. He might go outside and move around the building again. He might enter it and see the interior many times trying different points of view. He might look at the plan drawing lines over it. He might start decomposing the volumes and dissect the space. In other words, he will transform himself to the architect in order to make him speak through his own discoveries.

These discoveries are about a multiplicity of colliding levels of properties generating a multiplicity of colliding interpretations. Having transformed himself to the architect he might realise that all are equally valid. There is no single interpretation represented by a single figurative concept. However, there is a higher level interpretation that suggests: *Interpret this building in a way that probability and ambiguity is maximised.*

- **Ordinary and architectural experience - a discussion of buildings as works of architecture**

Analysis of these buildings showed that the two architects present themselves as external agencies staging spatial experience and expressing a concern for the serial and the synchronous aspects of this experience. Even Le Corbusier who disconnects the two levels of structure presents himself as a controlling authority. This authority points at the complexities of cognition within a constructive format which regardless of how decomposed it looks is present.

In this respect, experience of their buildings becomes the opposite of ordinary spatial experience. In ordinary experience invariant characteristics in the transformation of visual information define the structural parameters by which space and form become intelligible. Operational and figurative, sequential and synchronous concepts exist side by side configuring intelligibility of space.

Nevertheless, these concepts by which one makes sense of the world are taken for granted. There is no evidence of an external authority who challenges the normal perception of space. There is no evidence of an agency that points at the interactive levels of form and space, at an interaction based on a unity of interpretations or on a multiplicity of interpretations. There is no evidence of an authority that puts limits to these interpretations regardless of their multiplicity.

In these buildings there is an intentional authority aiming at setting cognitive principles at work which encapsulate the ways intellectual mechanisms govern spatial experience. Setting intellectual thinking in motion about these mechanisms these buildings reveal an intention to challenge and distinguish themselves from experience of ordinary buildings. In other works they reveal an intention to be works of architecture. The discussion following at the end of this thesis will examine this hypothesis.

# Part three

## A DISCUSSION OF BUILDINGS AS WORKS OF ARCHITECTURE

# DISCUSSION

## • INTRODUCTION

At the beginning of this thesis it was suggested that some buildings are capable of affording an experience that distinguishes them from others. They have been fashioned to engage their viewers and direct their attention to the intellectual mechanisms that give them shape and form. The property of some buildings to generate this interest was seen as lying in the recognition of an intentional shaping strategy. It was also seen as being based on the recognition of an innovative strategy that exceeds ordinary spatial experience as well as the products of an existing architectural practice. These buildings, it was proposed, can be considered as works of architecture.

Studying the selected buildings, analysis showed that Le Corbusier and Botta place an emphasis on their laws of construction. They potentially draw their viewers into a discovery of their shaping strategies. A review of the literary material also suggested that they both operate within a classical and modern framework creatively recombining existing compositional principles.

Reaching its final stage this study examines these propositions in greater detail. *The aim is to see under what conditions some buildings are different from others, what their constructing and innovative strategies are about and whether the buildings examined by this research have the characteristics of this class.*

It argues that architecture exists when there is recognition of a constructing strategy that moves from the existing patterns of a cultural and architectural production to the combinatorial possibilities released through the act of design. This strategy is about establishing new combinations of the interaction between the synchronous and the sequential organisation of space approaching composition as an innovatory activity in process.

Based on this definition this section also argues that architecture is recognised in both sets of buildings. However, Botta's innovatory potential is mainly based on a reshuffling of combinatorial solutions established by classical and modern architecture. In contrast, Le Corbusier extends beyond this to an exploration of combinatorial possibility released during a probabilistic compositional process.

## REVIEWING THE ARGUMENTS OF THIS THESIS

### Composition and the synchronous and serial organisation of space

To start a discussion about buildings as products of a constructive and innovative activity a review of the main arguments of this thesis is needed. This study has addressed the problem of how buildings are intelligible as physical systems. It raised the question of how intelligibility is structured as a result of the relationship between two levels of properties. One level captures relations that link physical and spatial elements into geometrical abstractions like lines, shapes and axes of symmetry in a synchronous plane independently of an observer's position in space. The other level captures relations in a diachronous plane that are sequentially learned by an observer through movement in time.

Using elementary examples and a sample of houses designed by Botta and Le Corbusier, this study showed that both levels of properties can be studied as the set of principles that remain invariant in the transformation of higher levels of articulation to lower ones. It proposed that space and form cannot be reduced to static principles independently of the dynamics of a process that gives rise to them. They are systems in which invariant properties and reversible operations establish interconnections amongst higher and lower states of development. A study of structure as a system in process enabled a study of a genesis and of the laws of composition. In this way, this thesis has showed that formal and spatial description is a description of composition as a dynamic constructing activity.

Two different transformation processes, a deterministic and a probabilistic process, were identified. In the former design is subjected to invariant relations that bind all levels of properties under a single organising principle of a higher level concept. In the latter design opens up to emergent relations that are negotiated with predetermined states of order. In the former invariant properties subject serial experience to the formal principles of a simple concept creating a single interpretation. In the latter sequential experience develops independently of formal properties generating a proliferation of readings and a perceptual ambiguity. In a deterministic process invariant properties experienced at the diachronous plane give access to the formal properties at the synchronous plane. In the latter properties are suspended and negotiated allowing the two planes to intersect as well as to develop independently of each other.

Thus, the analysis of these buildings showed *that the ways the two levels of structure interact and structure intelligibility is bound to a specific compositional logic.* These buildings are organised realms achieved by the constructing mechanisms of an external authority that intentionally articulates the relationship between the serial and the synchronous experience of space.

Therefore, Botta and Le Corbusier regard composition as a constructing activity entering into the activities by which space is grasped, i.e. synchronously as a result of the formal-geometrical interconnections that link separate events together and serially as a result of the spatial interconnections that become known by moving in space.

If these considerations reveal the architects' fundamental attitude towards composition, then to what extent can they suggest something about architecture in general? Is it possible to define the criteria by which the buildings selected by this study and buildings in general can be evaluated and discussed as works of architecture?

- **Architecture and the vernacular**

The previous chapter suggested that there is a fundamental difference between these buildings and buildings that are not results of an ordering mind, i.e. buildings that do not arise from a composing agency that intentionally seeks lawful ways of combining the spatial and formal properties.

Bill Hillier in an attempt to define what is architecture and what is not distinguishes architecture from the vernacular. He suggests that although this distinction changes with time[1], the rules the vernacular designer uses are taken for granted, while those of the architect are not. Whereas a vernacular building reproduces a socially accepted pattern using a set of existing normative rules, architecture goes beyond cultural reproduction 'into the realm of principled understanding'.

'What we mean by architecture surely is not building by reference to *culturally bound competences.* What we mean, rather, is building by reference to a would-be *universalistic competence* based on general comparative knowledge of architectural forms and functions, and aimed (through understanding of principle derived from comparative knowledge) at innovation rather than cultural reduplication. The judgement we make that a building is architecture arises when the evidence of systematic intent is evidence of intellectual choice and decision making exercised in a field of possibility that goes beyond cultural indiocyncracy and into the realm of principled understanding. It is when we see in buildings evidence of this concern for the abstract comparability of forms that building is transcended and architecture is named'.

For Hillier architecture is recognised by evidence of a theoretical intent that frees itself from cultural constraint striving for innovation. 'Architects are enjoined both to create the new, since this is the nature of their task, and to clarify and improve the theories that tie their creation to social existence'.

- **ARCHITECTURE AS A CONSTRUCTING ACTIVITY**

However, to be able to define what architecture is, it is necessary to define *not only how it differentiates itself from the vernacular but also how it does so and by what means.* Besides, the distinction between architecture and the vernacular has another crucial dimension. The vernacular designer, or even the

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1 'To make the matter even more difficult, the demarcation between architecture and the vernacular shifts with time, in that aspects of the architecture of one generation may appear as the vernacular of another and vice versa'. B. Hillier, 'Specifically Architectural Theory: a Partial Account of the Ascent from Building as Cultural Transmission to Architecture as Theoretical Concretion', Harvard Architectural Review, 1994, p. 9.

architect, who reproduces culturally accepted patterns is not preoccupied with the ways buildings are composed, i.e. the ways their elements come together into an organisational whole, and the ways they become grasped as results of composition. This is not to say that he is not intentionally engaged into a combinatorial activity the results of which are often of undeniable quality. However, his combinations are inscribed within the set of normative rules delivered by culture and aimed at serving cultural purposes rather than stimulating intellectual thinking.

*This is a preoccupation of the designer who realises that together with other purposes his building carries an extra level of content, i.e. it forms an ordered realm and expresses a shaping strategy that intentionally controls the performance of this building as a system of composition.*

Vernacular or ordinary buildings have order. However, this order is a result of the collective mechanisms of a culture realised through the individual action of the specific designer or builder. On the other hand, architecture has order but is also ordered. It is this difference between *carrying order* and *being ordered* that captures the difference between ordinary buildings and architecture. Behind architecture stands a designing authority, a creator delivering not simply products that serve social purposes but also constructing mechanisms, specific experiences and a set of intellectual operations.

It was suggested before that the constructing mechanisms are about a dynamic system consisting of operations and properties that articulate the relationship between the serial and the synchronous organisation of space. *Thus, it could be argued that architecture exists when there is recognition of a compositional strategy driven by a fundamental concern about the ways these two levels interact.*

In an analysis of the literary text Umberto Eco puts forward a similar proposition[2]. For Eco the work of art exists when it is possible to identify the shaping strategy of an author. Studying the ways narration is structured, Eco uses the Russian Formalists' distinction between *fabula* and *sjuzet* translating it into a distinction between *story* and *plot.*

The story of *Ulysses*, Eco explains, as it was probably known to the Greeks, progresses from an initial moment, T1, to moments T2, T3 until it reaches a final moment, Tx, i.e. from the time Ulysses leaves burning Troy and gets lost at sea, to the moments he escapes from horrible adventures and finally to the moment he arrives to Ithaca. The plot of the Odyssey, however, as written by Homer, is different. It begins at moment Tl when Ulysses is already Calypso's prisoner. Between this moment and moment Tl he escapes from Calypso, arrives at the island of the Phaeacians and tells his tale. From this point the story goes backward in time dealing with his previous adventures. It is only when Ulysses concludes his tale that the story progresses linearly again as he sets sail for Ithaca.

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2 Umberto Eco, 'Six Walks in the Fictional Woods', Harvard University Press, 1995, p. 116

Story and plot are structures the author uses to construct his narration. They form a grid outside the linear reading of the text. However, through this linear reading the reader follows a plot the material of which allows him to reconstruct the story, the sum-total of all the events in the narrative. Eco suggests that texts are written with the view to instruct a 'model reader'[3] who causes the text to reveal the constructing strategies of the story-plot interaction.

Although an analogy between architecture and literary text has certain limitations, it could be suggested that the story-plot interaction is analogous to the space-form interaction. The plot unfolds through the linear reading of the text. Space also unfolds sequentially through spatial experience. The story is accessed through a rearrangement of the events occurring in a specific order in the plot. Similalry, form is accessed through a re-arrangement of the spatial episodes into an organisational format independently of the order in which they are encountered and the positions they occupy in space. Finally, in the same way that the shaping strategies of the author are about the interaction between the story and the plot, the shaping strategies of the architect articulate the interaction between the serial and the synchronous organisation of space.

The composing architect stands as an authorial entity behind this interaction constructing a compositional device, a network of intersecting structures intended to attract attention and to be discovered. This network, it was argued, can be simple as in Botta's buildings, or complex like in Le Corbusier's buildings. Nevertheless, regardless of the simplicity or the complexity, the easiness or the difficulty in tracing a strategy, architecture creates finite, ordered worlds quite different from the worlds of ordinary spatial experience.

In other words, Hillier's notion of intellectual choice in a field of possibilities can be enriched by saying that this choice is about the relationship between the synchronous and the diachronous organisation of space. The architect's abstract comparative knowledge is about a field of combinatorial possibilities that bring these two planes together.

Besides, it could be suggested that these architects revealing a concern about these two planes express a concern that goes beyond the cultural and programmatic purposes of their buildings. Their work refers to the constructing and cognitive activities by which space is designed and experienced. Thus, together with their treatment as social artefacts their buildings are treated as systems of composition entering into the constructive and perceptual activities by which the world is perceived.

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3 The 'model reader' is defined as 'a sort of ideal type whom the text not only foresees as a collaborator but also tries to create', Ibid., p. 9.

Thus, architecture is different from building not simply because it moves from cultural constraint to architectural possibility and architectural freedom of a combinatorial realm but because it moves from these constraints to the combinatorial possibilities of two interacting systems of cognition.

It has been suggested that the viewer and the architect are complementary entities constructing each other in the process of designing and viewing a building. Thus, in the recognition of a shaping strategy lies an interaction between the creator and the user, the performer and the spectator. It is this interaction that sets intellectual thinking in motion, arising the interest of the viewer and offering the opportunity for employing his faculties for perceiving the world and reconstruct his spatial experience.

In other words, one of the parameters for recognising architecture is *evidence of a composing agency that intentionally devices constructing mechanisms that articulate the relationship between the serial and the synchronous organisation of space entering into the cognitive processes by which the world is grasped.*

- **ARCHITECTURE AS AN INNOVATIVE ACTIVITY**

The second parameter by which buildings can be considered as architecture is their innovative dimension. Innovation, it was suggested, is recognised in what becomes distinguished by its comparability and deviation from what is already known and socially accepted. It was argued that innovation operates in two levels. One is the level of building that does not qualify as architecture. The other is the level of architecture itself as this is presented by a given context of architectural practice.

In the first level, a building employing a shaping strategy and addressing issues of cognition, renders itself unusual turning familiar norms into something strange and unknown. Therefore, it could be said, that the novelty of a building starts from the moment a strategy is read.

However, new creations are made possible by comparative knowledge of ordinary worlds as well as of architectural worlds. New combinations are achieved and understood not only by reference to the culturally transmitted set of formal solutions but also by reference to the existing field of formal solutions achieved through previous architectural examples.

To examine how invention in a field of architectural production is achieved, the discussion returns to the buildings selected by this research. At the beginning of this study it was suggested that various authors measure the creative strength of the two architects or otherwise their capacity to achieve invention by the critical interpretation and re-embodiment of classical and modern strategies in their work.

If architecture aims at new combinations, because this is the nature of its task, and based on the proposition that architecture is about the organisation of the serial and the synchronous planes, it could be said that innovation lies in finding new combinations of the relationship between these layers. Thus, an examination of the creative potential of these architects is possible by looking at how classicism and modernism addressed the issues of this relationship.

It has been proposed elsewhere that classical architecture achieved a correspondence between the two layers of properties allowing the axis of symmetry to become the central processional axis and the principal axis of the facade. In a more detailed examination of classical layouts it was showed that the visual fields produced through movement along the axes linking a series of clearly demarcated enclosures retain invariant geometrical characteristics in the form of symmetry on these axes. Besides, visual fields produced from distant locations are symmetrical on the central axis organising the formal properties of the layout as a whole. In this way, invariant geometrical characteristics observed during spatial experience give access to the geometrical properties of the formal structuring of the building.

Botta also uses symmetry as well as a correspondence between the spatial and the formal organisation. Thus, his designing strategies resemble the classical ones. However, in his buildings the Palladian principle of clearly demarcated spatial enclosures is missing. On the contrary, the barriers between spaces are dropped allowing the binding role of the outer and the inner surfaces to be observed. A number of other parameters of the formal organisation also render themselves observable during spatial experience like the rhythmical spacing of the geometrical bays through the extensive coverage of the plans by overlapping spatial elements.

Surfaces and geometrical grids entering spatial experience is a characteristic that is alien to the classical modes of combination between the formal and the spatial properties. This is because the clearly bounded spaces of classical architecture usually disturb an extension of their defining surfaces beyond the limits of a single room. Besides, geometrical symmetry fashioned in a Palladian manner is alien to the modernist principles of composition.

Therefore, what is original in Botta's houses in relation to classical buildings is the ways the boundaries of a classically organised space that subdivide the interior into distinct spatial enclosures are broken to allow more variables of the abstract principles of form to be grasped. What is original in relation to modernism is the ways this fluid modernist space, which in modern buildings usually lacks symmetrical organisation, acquires a symmetrical format.

Le Corbusier's work placed in the classical context, in which the two planes usually coincide, is also a new interpretation of the relation of form to space. This is achieved through the different directions the two layers of structure take. Placed in the modern context, his buildings challenge the departure of modernism from centrality and symmetry through grid geometrical regularities disguised behind an asymmetrical organisation of formal and spatial elements.

It has been suggested that various authors like Colquhoun have attributed the creative strength of the two architects to the ways the elements of their buildings carry an extra referential capacity[4]. This discussion shows that the innovatory parameter in their work is not simply based on individual elements and on surface appearances. It is structural in character lying on the ways new combinatorial relations between structural systems are established.

Based on the above considerations, it could be argued that the buildings of the two architects, achieving new combinations between the two levels of structure within an architectural context, can be evaluated as works of architecture.

- **ARCHITECTURE AND COMBINATORIAL INNOVATION**

However, Botta's simple geometrical volumes and symmetrical layouts conform with certain formal and spatial conventions a culture possesses. In the review of the literature it was demonstrated how authors describe his buildings as simple geometrical shapes rather than as structural systems consisting of properties. It was argued that this approach is not only based on the absence of the theoretical and analytical means to discuss architectural form. It is also based on the property of simple geometrical concepts to be easily identifiable as figurative elements through a structural simplicity and a representation of their rules through their defining lines.

The structural aspects of a pattern carry meaning through the set of principles forming its structure. The representational parameters of this pattern carry the ways it becomes meaningful within a cultural context. Patterns carry both levels of meaning, an endo structural content through the ways elements are grouped into shapes and forms and an extra structural content through the various meanings society attributes to them. There is often a belief that abstract patterns like geometrical shapes carry a syntactic meaning, whereas figurative patterns, like relational systems amongst structural members, openings and so on carry meanings given to them by culture.

However, this study proposes that cultural meaning can be transmitted through abstract patterns too. These are simple geometrical shapes which become easily distinguishable and recognisable due to structural simplicity and an increased physical definition that gives them individuality and perceptual autonomy.

Although these shapes are structural entities defined by properties that stay invariant in a transformation group, the representation of their structural principles into a clearly identifiable contour turns them to

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4 Colquhoun has provided a list of these elements in Le Corbusier' work like Catalan vaults, ocean liners, factories and object types. Frampton has also attributed architectural quality in Botta's buildings through the ways he transforms existing typological solutions coming from the vernacular production of a specific region.

classes of objects or isolated elements. These are deeply rooted into the encoded sets by which the world makes sense and they are unconsciously used in the interpretations of cultural phenomena. The extra referential property of these patterns is demonstrated not only in the ways authors describe buildings using simple shapes but also in the ways they describe urban patterns as a collection of elements like urban blocks, streets and squares.

Botta's design process is directed by the principles of a simple shape from the large to the small scale articulation and from the level of the formal patterns to the level of the spatial ones. All structural layers in both formal and spatial levels of properties are bent and subordinated to the principles of this shape. This logic creates an intensification of the largest volumetric component and its axis of symmetry by virtue of an aggregation of surfaces, shape, grid and spatial components under their co-ordinating role. It strengthens both the structural and the physical aspects of the block and its axis raising them into the realm of representation. *Representation of the formal and the spatial patterns by a simple figurative concept is fixation arresting the possibilities for interpretation into a single reading known through cultural convention.*

Thus, a co-ordinated distribution of elements under the same principle of a simple shape strengthens the semantic parameters of a syntax. It reproduces a culturally bound system that reduces the capacity of the work to deviate from existing configurational norms. Analysis showed that it operates as a restriction in the field of possibilities released during the design process. *Design aiming at innovation and a design course that constantly directed by culturally accepted shapes and forms are not compatible. Thus, the problem architecture aiming at innovation faces is to release a combinatorial potential that can lead to subtle and less obvious ways in which the relationship between the synchronous and the diachronous plane is grasped.*

This seems to be Le Corbusier's preoccupation. His design logic suspends the properties of the higher level concept opening up to an exploration of combinatorial possibilities emerging through this suspension. At the same time the search for possibility is controlled by this concept which acts as a background for the deviation towards unknown forms. Analysis showed how this is made possible by a series of transformations that on the one hand take the form and shape in process away from the properties of the first stage, while on the other re-establish the priority of this stage.

This logic which groups elements in a variety of possible ways as well as in accordance with the properties of a simple shape creates a coincidence and an independence amongst various structural levels. At the level of formal properties this is manifested in a variety of ways mostly expressed in surfaces the defining lines of which enter into grid symmetry and shape asymmetry. It is also expressed in grid systems that are governed by a different axis of symmetry in each individual level, or by grid lines that enter into asymmetrical relations in the context of a single floor and into symmetry in the context of the grid systems of the building as a whole[5]. Another manifestation of this phenomenon is the use of interlocking elements the defining lines of which enter into more than one single shape definition[6].

At the level of spatial properties the simultaneous coincidence and independence between structural levels is made possible by surfaces that on the one hand bind spatial elements expressing a spatial connection, while on the other they group themselves independently from spatial connections giving physical definition to a single space only.

Regarding the relationship between the formal and the spatial properties this coincidence and independence is expressed also in a variety of ways one of which is the employment of symmetrical grids and asymmetrical visual fields. The lines defining shapes and spatial elements enter into symmetrical relations, whereas the physical and spatial elements as experienced in space have no symmetrical co-ordination.

These considerations show that there is *a multiple distribution of the same elements into many different combinations.* It seems that Le Corbusier uses existing patterns to limit his range of possible moves. At the same time he opens up within these limits a potential set of combinatorial choices. The examination of all layers and all levels of properties concluded that a tension in interpretation is generated based on principles that intensify higher level concepts and principles that deviate from these concepts. Thus, a multiple combination of elements is unable to produce a single fixed meaning releasing multiple interpretations. The release of combinatorial possibility results in a release of possibility in meanings that challenge patterns that are culturally taken for granted.

*Therefore, it is only through the internal laws of composition, through the act of creating and manipulating shapes during design, that formal possibility is released and innovation is achieved.*

- **ARCHITECTURE AND THE 'OPEN WORK'**

The notion of a multiplicity of interpretations created by a pattern that multiplies the formal distribution of elements in many possible combinations has been identified by a number of critics of art. The work of Arnheim and the Gestalt psychologist, for example, has been preoccupied with the ambiguous readings entailed in configurations where elements register in multiple figure and ground formations.

Umberto Eco suggests that the capacity of a work to create this multiplicity of interpretations and the sense of discovery characterises works of art that are primarily concerned with a kind of 'openness' and suggestiveness. Unlike 'closed' works which point towards a single concluded message, the open work or

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5 This is the grid produced by the superimposition of all grids used in the Volumetric Analysis Chapter.

6 This is a multiple distribution occurring at the same structural level which is the level of shape properties.

the 'work in movement' is susceptible to 'countless different interpretations which do not impinge on its unadulterable specificity'[7].

Starting with a number of recent pieces of modern music Eco claims that this characteristic is a result of a contemporary aesthetic. It expresses an ever growing awareness for the capacity of the work to hand in to its receptor innumerable possiblities of interpretations.

Herni Pousseur's *Scambi*, Eco says, 'is not so much a musical composition as a field of possibilities, an explicit invitation to exercise choice. It is made up of sixteen sections. Each of these can be linked to any two others, without weakening the logical continuity of the musical process. Two of its sections, for example, are introduced by similar motifs (after which they evolve in divergent patterns); another pair of sections, on the contrary, tends to develop towards the same climax. Since the performer can start or finish with any one section, a considerable number of sequential permutations are made available to him'[8].

Another example he provides comes from literature. In James Joyce's 'Finnegans Wake' each word stands in a series of possible relations with all others in the text. According to the semantic choice which we made in the case of one unit so goes the way we interpret all the other units in the text'[9].

Christopher Butler also suggests that this phenomenon characterised developments in many areas of modern art like poetry. 'The central concepts of the text were given new values by being put into defamiliarising juxtaposition, within ambiguously complicated networks of metaphoric association'[10]. In Cubist painting the same principle was expressed by the absence of a single way of seeing an object. Objects were fragmented into various elements which entered into many relations within the composition.

For Eco the development of this tendency can be traced back to Plato and Vitruvius[11] who pointed at the difference between objective proportions and the ways these appear to the eyes of the observer. However,

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7 Umberto Eco, 'The Role of the Reader, Explorations in the Semiotics of Text', Indian University Press, Bloomington, 1979, p. 49.

8 Ibid., p. 48.

9 Ibid., p. 54.

10 Christopher Butler, 'Early Modernism, Literature, Music and Painting in Europe, 1900-1916', Oxford University Press, 1994, p. 5.

11 'In the *Sophist* Plato observes that painters suggest proportions, not by following some objective canon, but by judging them in relation to the angle from which they are seen from the observer. Vitruvius makes a distinction between 'symmetry' and 'eurhythmy', meaning by this latter term an adjustment of objective proportions to the requirements of the subjective vision'. Umberto Eco, Ibid., p. 50.

its explicit appearance is marked by Baroque architecture. A subjective creativity is introduced for the first time in which the work remains somehow 'unfinished' asking for the interpeter's subjective responce, involvement and creativity.

Eco seems to follow the line of thought that separates objective properties from the ways these are experienced. In the review of the literary theory as well as in the analytic examination of the two sets of houses it was showed that there is no division between objective and subjective properties. Properties are embedded into the physical world either by virtue of a single rule that provides them physical definition and representational intensification or by virtue of many combinations that cannot be representated by a single element.

If a work involves a number of readings it does so not by virtue of subjective responses on the part of the viewer but by virtue of a specific kind of order which allows the elements to group themselves simultaneously into different systems. *It is a release of combinatorial possibility caused by a multiplication of distribution of elements in many combinations that generates this suggestiveness and openess in interpetation.*

In this respect, this thesis offers an understanding of what literary theory has defined as 'closed' and 'open work' in architecture. It also shows what are the constructing mechanisms that achieve these characteristics. Finally, it explains that a singular or a multiplicity of interpretations is a property of the work itself rather than characteristics attributed to the work by the beholder. As the viewer chooses to focus on one layer of properties or another or as he chooses to see a building from one point of view or from another different groupings of elements are picked up producing different readings. Thus, if there is a mental collaboration of the artist and the consumer this relies not on the capacity of the work to acquire meanings that are given by the receptor but on a prolonged attention, on his extensive engagement and on the sense of discovery this kind of work generates.

However, what is of interest in Eco's argument is not the theoretical assumptions that split the world of abstract geometrical pattern and the world of visual appearances apart. It is the idea of 'suggestiveness' as a phenomenon characterising certain works of art creating a continuous potentiality, an indefinite reserve of meanings.

This suggestiveness precisely because it affords multiple combinations appears expansive encompasing cognitive possibilities. If the characteristic of art and architecture as it was suggested before is a synthesis and an innovation in a cognitive realm, then what follows is that *cognitive suggestiveness pushes the work of art to a continuous renewal of cognitive processes through a multiplicity of combinatorial potential aiming at maximum innovation.*

It was mentioned before that Botta achieves a certain originality in his work. He reinterprets the classical idea of a centre within a modern open space. In his interior a multilayered space is created through overlapping visual fields that expose the classical symmetrical structuring of the building through a network of explicit and implied geometrical elements. The overlaid convex spaces become a spatial interpretation of the cubist overlaid layers of planes transposing also a modernist aesthetic into the realm of classical composition.

It could be said, therefore, that Botta's innovation lies in the reinterpretation of the classical and modern space. Le Corbusier's innovation lies both in the new ways of addressing the issue of clasical and modern architecture as well as in finding new ways in which shapes and spaces come together to constitute a system of cognition. In other words, Botta creates new combinations within existing architectural practices. Le Corbusier creates new combinations within these practices as well as within a general field of geometrical and spatial combinations.

Botta sacrifices innovation in the general field of combinatorial and perceptual possibility for the ability to stand at one point and understand the whole as well as for the ability to recombine the classical and the modern. The ability to stand at one point and understand the whole has no attraction for Le Corbusier. It was achieved by classical architecture. Le Corbusier sacrifices the ability to stand at one point and understand the whole for the ability to challenge the usual ways in which existing practices have combined the two as well as for breaking down conventions of an intelligible order. Botta aims at innovation within an existing practice. Le Corbusier aims at maximum innovation within an existing practice as well as within a general field of combinatorial possibility.

*These considerations seem to show that architecture is a constructing acitivity that creates new suggestions about the ways buildings work as cognitive systems within a given cultural context of everyday building, a given architectural context and a more general context of combinatorial potential in the realm of cognition.*

- **ARCHITECTURE IN PROCESS**

The characteristics of Le Corbusier's work were shown to create certain responses to the viewer of his work. These responses are prolonged attention, constant engagement and the sense of multiple discoveries through new perspectives and surprises encountered during the course of movement.

For Eco such characteristics express the mutually contrasted epistemological situations, the lack of a privileged point of view and the validity of all available perspectives. From antiquity to modern times there has been a close interrelation between science and art. The developments in the area of optics, for example, identifying a distinction between the object as it is and as it is experienced by the eyes of a perceiving subject have been inseparable from the development of perspective in the Renaissance period.

Hillier's proposed distinction between science and art is that science tries to encompass as many phenomena with as few abstractions while art tries to encompass as many abstractions with few phenomena[12]. Based on this distinction it could be argued that if artists are drawn to science it is neither to borrow models from it nor to symbolise scientific developments as Robin Evans suggests[13]. It is not because artistic forms reflect the way in which science or contemporary culture view reality as Eco claims either. It is because science's preoccupation comes close to those of the artist's. This preoccupation is with the provision of theoretical propositions that explain the variety of the life phenomena. So, if refutability makes a scientific theory a good theory, then it could be said, that innovative potential is what makes a good work of art.

Innovation understood in the context of an existing pattern from which the work of art deviates is nothing other than refutation of this pattern. The work of art presents what is existing and what is new in this cognitive realm making the world to be seen in a different way in the same way that a good theory surpasses another one adding something new to the ways in which this world is explained. In this sense a work continuously opening up to a combinatorial cognitive realm seeks new perspectives in the activities in which the world is grasped striving for maximum aesthetic potential.

This thesis has shown that one of the ways in which this becomes possible is through a design process that also opens up to probabilities. In other words, it shows that the creative potential is incorporated within the act of designing. This thesis tries to take the notion of architecture and creativity further into the realm of composition by suggesting that architecture is a composing, theoretical and innovative activity in process that expresses and surpasses comparative knowledge by continuously exploring combinatorial and cognitive potential through the pragmatics of this process. In the same way that in science hypotheses and abstractions are held until knocked down by the pragmatics of physical phenomena.

It is this capacity of a work of art and architecture to explore combinatorial and cognitive possibilities that can lead to a conjecture that Le Corbusier's work continues to thrill and will continue to thrill. Its innovatory potential has a trajectory far more expanding and far more lasting than Botta's.

This is not to deny the aesthetic dimension of every artistic work that is not characterised by this openess. The open work and the identification of its aesthetic dimension by this discussion do not define general criteria for what the aesthetic is. This discussion has defined general criteria about what architecture and art is. The aethetic evaluation of each work has to be seen within the specific cultural

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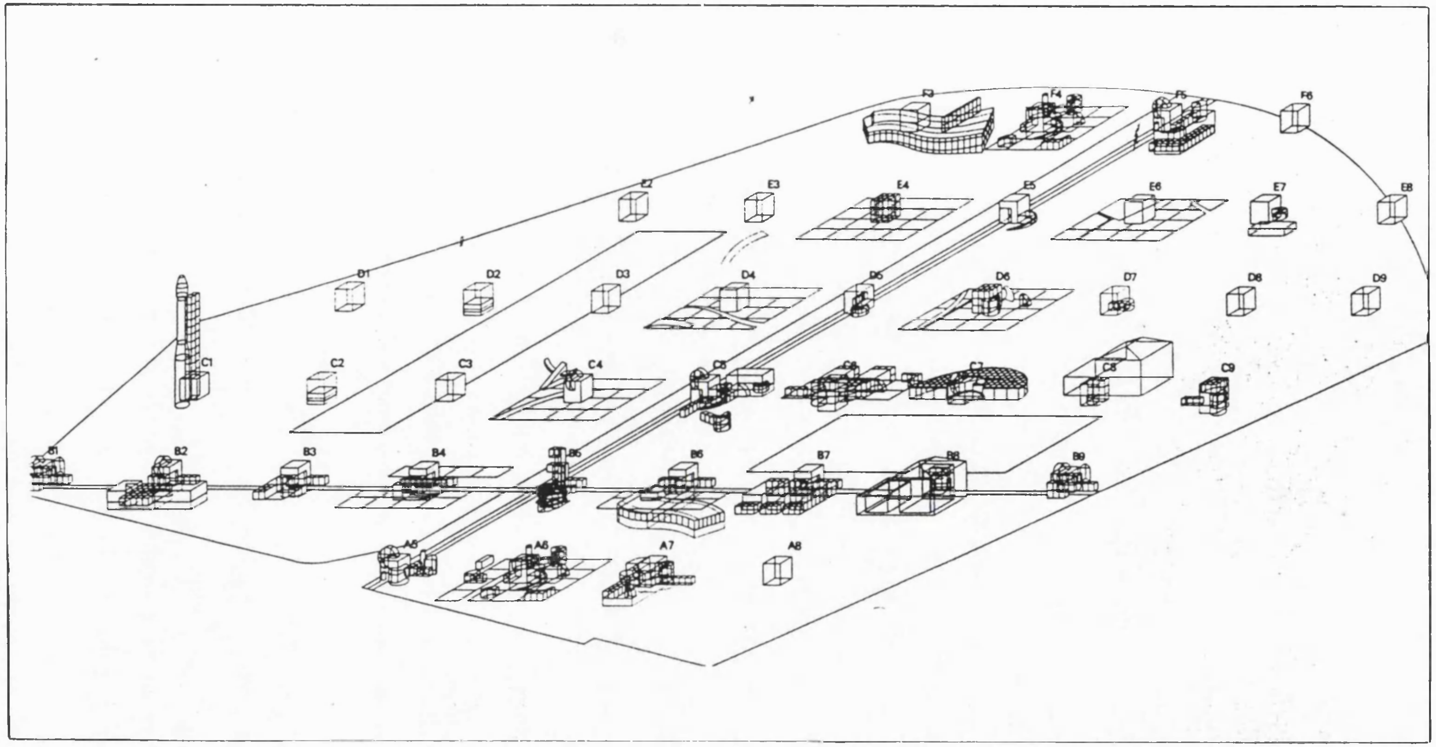
12 Ibid., p.p. 24-25

13 Robin Evan, 'The Projective Cast, Architecture and its three Geometries', The MIT Press, 1995, pp. 348-349.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(1)

context in which it operates, in the same way in which Botta and Le Corbusier are examined within the architectural contexts of classicism and modernism.

For Eco the open work has opened a new chapter in the history or art. '... the situation of art has now become a situation in development. Far from being fully accounted it deploys and poses problems in several dimensions. In short, it is an open situation, in movement. A work in progress[14]'.

However, this situation is not new. It has been in constant process since Plato and Vitruvius, as Eco suggested contradicting himself, who observed the difference between 'the thing as it is', i.e. as a rational system of geometrical order, and the thing as seen through the observer's relative position. It has been present all the way since then from the Renaissance and Baroque architects and artists to the moderns. In modern times it reaches a development in which architects become more and more aware of its significance and try to incorporate and express it in their work. The development of deconstruction is an aspect of this awareness in which an exaggerated departure from the intelligible order has taken place expressed through the disjointed members of buildings. Tschumi's juxstaposed layers of combinatorial systems, ('point grids', 'cinematic promenades' and 'surfaces'), in Parc de la Villette, (illustration 1), are manifestations of a departure from Classicism in which layers are brought together under a single rule.

If artistic innovation is related to the culturally accepted forms by virtue of deviating from these forms, deconstruction shows that classicism and modernism are still casting their overpowering shadow through their familiar formats. Architectural explorations pushing the limits for new combinations seek their aesthetic significance by moving further and further away from classicism and modernism. It is not suggested here that all examples of deconstruction are works of architecture. What it is suggested is that they strive to be architecture[15].

Classicism expressed an omnipresence, i.e the capacity to stay at one position knowing aspects of those positions that are not visited. The physical limitations of a body that cannot occupy multiple positions were overcome by a system that brought space and shape under a single rule through symmetry and centrality. For axes to be visible, they had to bring as many physical elements as possible under their

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14 Ibid., p. 65.

15 This is most clearly expressed in the writings of Peter Eisenman where an extensive reference to the differences between his work and classicism and modernism is made. However, as Galdesonas has suggested, in Eisenman's work the juxtaposition of structural systems derive their signification not from their syntactical positioning but from a constant criticism and symbolism of the notion of syntax. Mario Galdesonas, 'From Structure to Subject: The Formation of Architectural Language', introduction in the book 'House X', Rizzoli International publications, 1982, p. 30. Besides, His emphasis on the self referential sign, as it has been suggested in the literature review chapter, is another expression of the ways he regards syntax to carry not its own meaning but to signify itself.

organising role. Thus, the limitations of the human body were overcome by an embodiment of geometry into the visible body of the building.

Modernism as employed by Le Corbusier took physical definition away from geometry. It left the underlying network of geometry a mere skeleton forcing the body to move in order to see the developing course of architecture. In this way, it expressed the same principle in reverse. The human body cannot overcome its physical limitations.

*Thus, both classicism and modernism expressed that architecture lies in this subtle balance between two roads. One road moves along abstractions that enable the human mind to transcend the limitations of the body. The other moves along concrete reality in which one is lost in the detail, in the pragmatics of a world in which he has to discover what path to walk in.* This has been the underlying principle in all manifestations of culture from science which attaches models to the everyday phenomena to religion that since the ancient times has claimed that this labyrinth has an author.

This *seems also to be the underlying philosophical principle behind the work of art.* Art recognises that everyone is in the labyrinth considering where to go next. In contrast to the actual world which streches beyond the limits of science and imagination, art constructs a finite universe that has an author. Some authors like Botta offer their viewers a clear path and access to knowledge. Others like Le Corbusier remind their viewers that knowledge of this finite and presumably of the infinite universe is unlimited because it assumes the form of a continuous permutation and interogation, like his compositions in process.

If art captures aspects of reality following the ways in which scientific and technological development accesses or creates new aspect of reality then what opens the ground for further development and exploration seems to be cyberspace. Cyberspace offers a new direction to philosophical issues addressing the relationship between the two worlds. It frees man from his physical limits and allows him to inhabit different, separate and disparate places. Shape and centre celebrated their presence in the body of architecture or their absence in the invisible skeleton of architecture to express the tension between the physical limitations of the human body and the capacity of the human mind to occupy a world of combinations. What seems to follow is another story. One could possibly suggest that cyberspace taking away the physical identity of the human body celebrates the vacuum of a virtual world, a world of limitless possibilities to which architecture and art in proccess cannot but seek to respond.

# APPENDICES

- **APPENDIX 1**

## Chapter Three - VOLUMETRIC ANALYSIS

- **MARIO BOTTA**

- **HOUSE AT PREGASSONA - (B H 2)**

- **GENERAL DESCRIPTION, (illustrations 3.18-3.22, p. 168)**

Situated on a hillside north of Lugano this house is approached through a path that curves slightly to the left allowing views of the principal and the its east facade, (illustration 3.18, p. 168). Like the house at Viganello it is a concrete brick and glass block that investigates the principles of excavation of a single volumetric form.

The house is organised around two geometrical axes running from north to south and from east to west. Three vertical voids are located along these axes forming the only devices that bring light into the house. Distribution of these voids along the perpendicular axes subdivides the cube into four solid elements located at the four corners.

The front glazed shaft cuts through the building in full height. It slices the front elevation in two equal halves and gradually closes off towards the top to terminate into a roof skylight, (illustration 3.20a, p. 168). The front of the building becomes its principal face articulating the entry and inviting the visitor into a journey through the house. The rear elevation is also symmetrical about a central stair drum that is flanked by glazing at the first and second floor, (illustration 3.20b, p. 168). The two sides are pierced at the centre towards the ground, glazed at the first floor and terraced at the upper level, (illustration 3.13c, p. 168).

The same model of integration of the various floors around the central void is used in this project. The ground floor accommodates the service facilities and a spacious portico for outdoor activities protected by the four corners of the masonry walls. The first floor houses the day activities, while the third floor contains the bedrooms that open towards two symmetrically placed terraces at the sides of the volume, (illustration 3.21a, b, c, 3.22, p. 168).

Table **BH2 3.1**

| 1 | 2 | 3 | 4 | 5 | 6 | |
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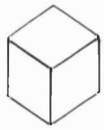
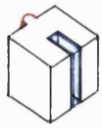
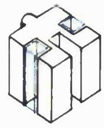
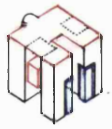
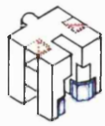
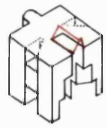
|  |  |  |  |  |  | |

## DESCRIPTION OF STAGES

The house at stage one is described by a single rectangular volume, (TBH2 3.1, fig. 1). This volume is symmetrical along two axes passing from its geometrical centre, (TBH2 3.2, fig. 1, p. 158).

At stage two a rectilinear volumetric rectangle is subtracted from the block, (TBH2 3.1, fig. 2). A vertical shaft is defined that extends from the bottom to the top of the house. The volume is transformed to a volumetric U. Further, a semicylindrical element is attached at the opposite side[1]. This element extends also from the ground to the top and projects outside the perimeter of the house.

The geometrical centres of the block, of the shaft and of the semicylinder are covered by the same BF axis, (TBH2 3.2, fig. 2, p. 158). The geometrical grid consists of three bays at length and of two bays at width, (TBH2 3.3, fig. 2, p. 158). From left to right the grid bays progress in the following sequence: B A B. Thus, symmetry and tripartition is employed at length of the configuration.

At width the two geometrical zones enter into symmetrical relations with respect to the horizontal line defining the shaft. This line coincides with the LR axis of the block. However, the grid is not symmetrical as a whole along this axis. This is because the curve at one side of the axis has no equivalent curve at the other side.

At stage three two volumetric rectangles are subtracted from the left and the right sides of the volumetric U, (TBH2 3.1, fig. 3). Two vertical shafts are defined that equal the height of the volume.

The geometrical centres of the two shafts lie on the LR axis of the block, (TBH2 3.2, fig. 3, , p. 158). The grid consists at length of alternating wide and narrow geometrical bays that proceed in the sequence : E D A D E, (TBH1 3.3, fig. 3, p. 158). At width it consists of three geometrical bays that progress according to the rhythm: F C C F.

At length the grid is symmetrical with respect to the BF axis. The side bays defined at stage two are sectioned into two bays in a way that the new arrangement is tripartite with respect to the central geometrical bay. At width the geometrical bays enter also into tripartite relations. The LR axis controls the placement of the side voids and of their defining lines but it does not organise symmetrical relations of the volume as a whole. On the contrary the BF axis divides the volume into two corresponding halves that interchange positions if the arrangement is reflected on it.

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1 This forms the stair drum.

At stage four the roof is extended to cover the side facing shafts, (TBH2 3.1, fig. 4, p. 461). Besides, the front void is widened at the base by the removal of two equilateral triangular volumes that extend from the ground to the second floor. Finally, two identical volumetric rectangles are inserted inside the side voids.

At the ground floor section the triangular elements are symmetrical along the BF axis of the block. (TBH2 3.2, fig. 4, p. 158). These elements add two oblique lines to the grid that are also symmetrical along this axis, (TBH2 3.3, fig. 4, p. 158). The geometrical bays progress according to the sequences described at the previous stage. Therefore, the grid is symmetrical as a whole along the BF axis and tripartite along the central geometrical bays running from back to front and from left to right.

The first floor section, is different from the ground floor section only in terms of the rectangular units inserted inside the side shafts, (TBH2 3.2, fig. 10, p. 158). However, the defining lines of these units coincide with the defining lines of the shafts, (TBH2 3.3, fig. 10, p. 158). Thus, the properties of this section coincide with the properties of the ground floor section. Therefore, the first floor section seen both as a configuration of components and as a configuration of grid lines is symmetrical along the BF axis and tripartite in both directions[2]. The roof plan changes to the condition discussed at stage two being, thus, symmetrical along the BF axis and tripartite with respect to the central geometrical bay, (TBH2 3.2, TBH2 3.3, fig. 22, p. 158).

Looking at the superimposition of all sections, (TBH2 3.2, TBH2, 3.3, fig. 28, p. 158), it turns out that the BF axis organises overall symmetrical relations not only of each individual level but also of the volume as a whole. The LR axis co-ordinates only the side shafts and their defining lines so that the arrangement cannot be divided into two equal parts at width.

At stage five two volumetric trapezoids that extend from the ground to the first floor are removed from the volume increasing the span of the void at the base of the building, (TBH2 3.1, fig. 5, p. 461). Besides, two volumetric triangles are added inside the side voids on the second floor. They are attached to the surfaces of the shafts transforming the shape of the terraces from rectangles to trapezoids.

At the ground floor section the subtracted elements and their defining lines are symmetrical with respect to the BF axis of the block[3], (TBH2 3.2, TBH2 3.3, fig. 5, p. 158). From left to right the geometrical bays proceed according to the rhythm: G D D A D D G. Therefore, the geometrical bays enter into

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2 The third floor section is not discussed here since it is only the ground and the first floor sections that change at this stage.

3 There are no changes on the first floor section. and on the roof plan. So, analysis looks at the properties of the other two sections only.

tripartite relations with respect to the central one. From back to front the arrangement of the grid bays remains as it is defined at the previous stages

At the second floor section the two triangular elements and their defining lines are symmetrical with respect to the BF axis, (TBH2 3.2, TBH2 3.3, fig. 17, p. 158). Both at length and at width the grid properties of this section remain as defined at stage four.

Looking at the superimposition of all sections, (TBH2 3.2, TBH2 3.3, fig. 29, p. 158), it turns out that the geometrical bays from left to right progress as following: G D D A D D G. From back to front the F C C F sequence defined at the previous stages still remains. Thus, the BF axis is the only axis that organises symmetrical relations of the volume as a whole. The LR axis operates on a local level organising relations among less elements.

At stage six a glazed pyramid covers the top of the front facing shaft, (TBH2 3.1, fig. 6, p. 461). The defining lines of this element coincide with the defining lines of the front void. The shape and the grid geometrical properties of this stage, thus, remain as they are defined at the previous stages, (TBH2 3.2, 3.3, fig. 24, p. 158).

- **COMPARISON ACROSS STAGES**

- **Physical properties**

Volumetric subtraction, planar extension and volumetric addition transform the volume along the analytic sequences. At stages two and three subtraction reduces the physical definition of the front, the left and the right surfaces as well as of the top three horizontal edges of the volumes, (TBH2 3.1, fig. 2, 3, p. 461). However, the volumes are hollowed out in a way that a solid element is defined at each corner. Thus, all the vertexes of the block retain physical definition.

Subtraction at stages four and five increases the width of the front void towards the ground reducing the physical definition of the front surface, (TBH2 3.1, fig. 4, 5, p. 461). However, it does not affect the solid volumetric units at the corners. Further, the extension of the top horizontal surface at stage four redefines the two horizontal edges of the block and increases its physical definition.

Volumetric addition transforms either the side facing voids, or the top of the building without affecting the physical appearance of the initial solid, (TBH2 3.1, fig. 5, 6, p. 461). The block retaining all its vertexes retains also its identity as a single physical object.

Thus, there seem to be certain constraints affecting the transformation of the volume at each stage. These constraints require the eight vertexes of the initial solid to retain their physical demarcation at every stage of the analysis. Preservation of the vertexes of this solid preserves its physical definition and consequently its concrete solid appearance as a physical object.

Further, there are certain constraints creating a differentiation between the front and the side voids. Whereas the former is enlarged, the latter are subdivided into sub voids. Whereas the front void remains uncovered, the side voids are covered by the roof plane. The former, thus, assumes a dominant role in the composition. Its priority over the others reassures the priority of the volumetric U of stage two over the components introduced at the later stages of the analysis.

- **Geometrical properties**

At each stage the subtracted and the added elements together with their defining lines are symmetrical with respect to the BF axis of the block. Thus, the geometrical properties of these elements and the geometrical properties of the grids they generate coincide.

Besides, this axis organises symmetrical relations among the elements of all horizontal sections. Therefore, it divides the building as a whole into two equivalent halves controlling geometrical relations on a global scale.

As the number of elements that are co-ordinated by the BF axis is increased, the strength of this axis is increased also. Further, a gradual intensification of the central geometrical bay is constructed by an increased number of geometrical bays that enter into tripartite relations with respect to it.

Symmetry and tripartition along the left to right direction is introduced at the middle and the final stages. However, both the LR axis and the LR central bay assume a secondary role co-ordinating only local relations. This shows that the transformation process constantly ensures the priority of the geometrical properties of the first stages over the properties of the following stages.

The comparative analysis of all stages reveals that transformation of the volume preserves the physical and the geometrical properties of the simplest volumetric element. These properties are reapplied in every step of the process in a way that the rules governing the small scale articulation (last stages) are embedded into the rules of the large scale (first stages). This results in a hierarchical distinction among the stages that establishes also hierarchical distinctions among the elements introduced at these stages.

• **H O U S E A T M A S S A G N O - ( B H 3 ).**

• **GENERAL DESCRIPTION, (illustrations 3.22-3.25, p. 169)**

The house is set on a steep slope facing a valley at the rear of the city of Lugano. Like the two houses examined before it is a single block that is excavated to accommodate an entry and terraces that are inscribed inside the volume, (illustration 3.22, p. 169).

A paved path that travels parallel to the principal facade leads the visitor to the entry located at the north side. It is only the front elevation that is entirely exposed to the views towards the east, (illustration 3.25a, p. 169). The other three sides sink into the sloping ground, (illustration 3.25b, c). A broad round opening is cut out from this elevation exposing the horizontal layering of the house into three floors. This circular aperture allows views towards a vertical shaft that is located at the centre of the building and crowned by a triangular skylight at the top of the house. It also exposes a double storey terrace lying in between the vertical shaft and the front plane, (illustration 3.23b, p. 169). A system of sliding glass partitions transforms this terrace to a conservatory.

The terrace opens towards one side of the volume creating a large vertical opening at the south facade. A narrow slot that terminates to a small rectangular opening pierces the south and the north elevations bringing a luminous beam inside the house, (illustration 3.25c, p. 169). The back elevation is symmetrical along the stair drum that projects towards the exterior, (illustration 3.17b, p. 169). Symmetry is intensified by two circular openings as well as by two vertical slots located at both sides of the drum.

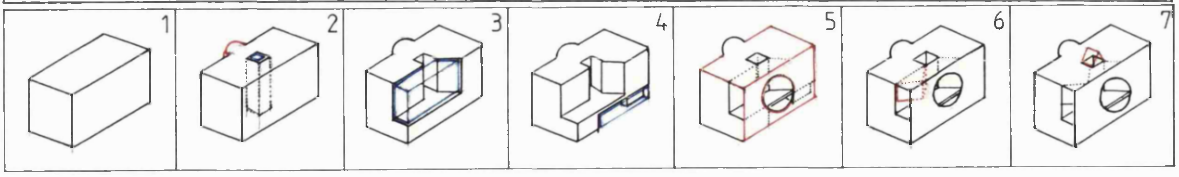
At the ground floor are the service areas and an entryway that travels parallel to the front plane in the manner of a loggia, (illustration 3.24c, p. 169). This loggia turns on the central axis to lead to the core of the house. The day activities are located at the first floor gathered around the vertical shaft, (illustration 3.24b, p. 169). Finally, two bedrooms are situated at the top floor facing into the terrace below. On either side of the stair drum a bathroom is found situated at the back of the house, (illustration 3.24a, p. 169).

• **DESCRIPTION OF STAGES**

At stage one the house is described by a single rectangular volume, (TBH3 3.1, fig. 1, p. 466). This volume is symmetrical with respect to two axes that pass from its geometrical centre, (TBH3 3.2, fig. 1, p. 173).

At stage two a rectilinear volumetric element is subtracted from the centre of the block, (TBH3 3.1, fig. 2, p. 466). A vertical shaft is created that extends from the base to the top of the volume. A

Table **BH3 3.1**



semicylidrical drum is also attached to the back surface[4]. This element extends throughout the height of the block and projects outside its perimeter .

The BF axis of the block covers the geometrical centres of the shaft and of the semicylinder, (TBH3 3.2, fig. 2, p. 173). The centre of the shaft lies also on the LR axis of the block. This arrangement is symmetrical if reflected on the BF axis but asymmetrical if reflected on the LR axis[5]. Thus, the former controls the configuration as a whole whereas the latter controls fewer elements.

The lines that define the shaft and the lines that are tangent to the semicylinder generate a geometrical grid that consists of five geometrical bays at length and three bays at width, (TBH3 3.3, fig 2, p. 173). From left to right the grid bays are arranged as following: C B A B C. From back to front the sequence is: D A D.

If the grid is reflected on the BF axis the lines on the right of the axis will be moved to the lines on the left and vice versa. If the grid is reflected in the LR axis the grid lines and the side bays will take the position of one another. However, there is no curve at the front equivalent to the curve at the back. Thus, the grid is symmetrical and tripartite both at length and at width. However, symmetry at width appears stronger than symmetry at length articulating relations at the level of the volume as a whole.

At stage three a volumetric trapezoid is taken away from the volume, (TBH3 3.1, fig. 3). A void is defined that extends from the centre to the left side and from the first floor to the top of the volume. The subtraction of this unit opens the shaft, that is created at stage two, towards the front.

The new void is not a symmetrical element, (TBH3 3.2, fig. 10, p. 173). It is not described, therefore either by any axis on its own or by any of the BF or the LR axes of the block[6]. Thus, this element breaks the overall symmetry of the shapes defined at the previous stages both at the first floor plan and at the level of the volume as a whole, (TBH3 3.2, fig. 31, p. 173).

An oblique line is added to the grid that has no equivalent line with respect to either the BF or LR axes, (TBH3 3.3, fig. 10, p. 173). Nevertheless, it generates two vertical lines that start from the points it intersects with the two horizontal lines defining the block. The new grid consists of seven bays at width that are arranged according to the rhythm: D E B A B E D This grid is characterised by tripartition. At length the properties of the grid remain as they are defined at stage two.

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4 This component accommodates the staircase.

5 This is because the semicylindrical element has no equivalent element at the other side of the LR axis.

6 The section cutting through the ground floor remains as it is defined in stage two, (TBH3 3.2 fig 3, p. 173). The first floor, the second floor sections and the roof plan are identical, (TBH3 3.2 fig 10, 17, 24, p. 173). Therefore, analysis discusses only one of these sections.

The oblique grid line is set against symmetry along the BF axis. Nevertheless, the arrangement of the grid is governed by symmetry as a whole to a greater extent than the arrangement of the shapes is. This is because in the former only one out of eleven lines deviates from overall symmetry, (1/11), whereas in the latter one out of four shapes falls outside the co-ordinating role of the BF axis, (1/4)[7].

*Thus, although the arrangement seen as a configuration of shapes lacks overall symmetry, seen as a configuration of grid lines is symmetrical and tripartite if the oblique line is excluded. Thus, at this stage there is a dissociation between the properties of the shapes and the properties of the grid.*

At stage four a volumetric unit is subtracted from the block extending from the centre to the right and from the ground to the first floor, (TBH3 3.1, fig. 4, p. 466).

The new void is not a symmetrical element with respect either to the axes of the block or to any other axis, (TBH3 3.2, fig. 4, p. 173). Thus, the ground floor section seen as a configuration of shapes ceases to be symmetrical as a whole along the BF axis. The superimposition of all sections is not governed by symmetry either, (TBH3 3.3, fig. 32, p. 173).

The geometrical grid consists of seven geometrical bays at length that progress as following: F G B A B H I, (TBH3 3.3, fig. 4, p. 173). At width the bays are organised according to the rhythm: D A B I. There is no symmetry and tripartition operating either at length or at width of the configuration.

The grid created by the superimposition of all grids consists of eight bays at length that are arranged according to the sequence: D H G B A B H G D, (TBH3 3.2, TBH3 3.3, fig 31, p. 173). At width the organisation of the grid bays is based on the following rhythm: D A B I. Both these patterns are not characterised by symmetry and tripartition. Thus, the asymmetrical organisation of the ground floor grid breaks the symmetrical and tripartite organisation of the volume as a whole at the level of the grid properties also.

At stage five the front surface of the volume is extended towards the left and towards the top to enclose the voids and redefine the top horizontal and the front vertical edges of the block, (TBH3 3.1, fig. 5, p. 466). A large circular opening pierces this plane exposing the ground, the first floor voids and the shaft. The roof plane is also extended reaching the left, the right and the front horizontal edges of the volume. It covers the top void leaving exposed only the top side of the shaft.

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7 The superimposition of all sections creates a grid that is similar to the grid of the first floor. Thus, it has the same properties with the ones described before.

The axes passing from the geometrical centre of the circular opening coincide with the axes passing from the geometrical centre of the front surface of the block[8], (fig 3.7, p. 203). Thus, the front elevation is symmetrical as a whole along the central axis[9]. The planar extensions of these planes do not cause any changes to the geometrical properties of the ground, first and second floor sections, (TBH3 3.2, 3.3, p. 173). So, the properties at this stage remain as they are described at stage four. It is only the roof plan that changes returning to its original shape defined at stage two. Thus, it is characterised by the properties described at that stage, (TBH3 3.2, 3.3, fig. 23, 26, p. 173).

At stage six an isosceles volumetric triangle is inserted inside the top void at the second floor, projecting over the first floor terrace, (TBH3 3.1, fig. 6, p. 466). One of its vertical surfaces is attached to the front facing surface of the void, while its front edge is tangent to the front surface of the volume.

The axis passing from the geometrical centre of the triangle does not coincide with the BF axis of the block, (TBH3 3.2, fig. 20, p. 173). Further, there is no equivalent element situated on the right side of the BF axis. Thus, this section seen as a configuration of shapes is not governed by symmetry along the BF axis as a whole. The superimposition of all sections results in a configuration that is also asymmetrical, (TBH3 3.2, fig. 34, p. 173).

The new element introduces two oblique lines to the grid, (TBH3 3.3, fig. 20, p. 173). One of these lines is equivalent to the line introduced by the oblique surface of the first floor void with respect to the BF axis. It also generates two vertical lines that coincide with the lines generated by the first floor surface. The oblique line close to the left side of the configuration has no equivalent line at the other side of the BF axis.

At this stage the grid is both symmetrical and tripartite if the second oblique line is excluded. The ratio of the lines that are not symmetrical to the lines that are symmetrical along the BF axis is 1/15. In terms of shape properties this ratio is 2/5. Thus, the role of the BF axis as a line co-ordinator is stronger than its role as a shape co-ordinator. In this respect a dissociation is created between the properties of the shapes and the properties of the grids.

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8 In this house analysis looks also at the front elevation because it plays an important role in the three dimensional articulation of the volume.

9 The line of the ground and the oblique cut at the left side of the facade break the pattern of symmetry. However, the large size of this opening and its central position create a simple arrangement in which symmetry prevails as the principal organising rule .

If the superimposition of all sections is examined, (TBH3 3.3, fig 34, p. 173), it turns out that there is no overall pattern of symmetry and tripartition governing the arrangement[10]. Thus, the asymmetrical treatment of larger system of grids is set in opposition with the treatment of the first and second floor levels that are 'just about' symmetrical.

At stage seven a glazed pyramid is added at the top of the vertical shaft extending outside the perimeter of the volume, (TBH3 3.1, fig. 7, p. 173).

The lines defining this element coincide with the lines defining the vertical shaft, (TBH3 3.2, TBH3 3.3, fig. 28, p. 173). Therefore, the geometrical properties of the roof plan at this stage are similar to the ones identified at stages five and six. Similarly, the geometrical properties of all sections are similar to the properties discussed at stage six, (TBH3 3.2, TBH3 3.3, fig. 35, p. 173).

- **COMPARISON ACROSS STAGES**

- **Physical properties**

Like BH1 and BH2 the operations transforming this house are volumetric subtraction, volumetric and planar addition and planar extension. Transformation starts at stage two by subtraction without affecting the external appearance of the block. Thus, all its surfaces apart from the top surface, all its edges and all its vertexes retain their physical definition, (TBH3 3.1, fig. 2, p. 466).

Subtraction continuous at stages three and four reducing the physical definition of the left and right vertical edges, as well as of the top left and front horizontal edges of the block, (TBH3 3.1, fig. 3, 4, p. 466). It also reduces the physical definition of the left, the right, the front and the top horizontal surfaces. Finally, the top left and the bottom right vertexes are not defined by physical elements at all. At these stages the block is deformed loosing its physical demarcation and its recognisability as a physical element.

However, planar extension of the front and the top surfaces at stage five reconstructs its contour, (TBH3 3.1, fig. 5, p. 466). Besides, the central void remains exposed at the top as opposed to the other voids that are covered by surfaces. The former assumes a dominant role in the composition stretching from the base to the top of the building, while the latter are secondary elements that cover the height of a single or two floors. Thus, the exposure of the central void at the top preserves the hierarchical distinction among the three voids as well as the hierarchical distinction between the second, the third and the fourth stage.

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10 The sequences of the grid bays at length and at width of the configuration are similar to those described at stage 4, (TBH3 3.3, fig. 32, 34, p. 173).

Finally, volumetric addition does not alter the physical condition of the block, (TBH3 3.1, fig. 4, p. 466). The isosceles triangular volume and the glazed crowing at the top of the house alter only the articulation of the top void and the articulation of the top of the shaft respectively.

Thus, at the beginning of the transformation process the external physical appearance of the initial solid is preserved. At the following stages the block is decomposed to a volumetric component that no longer preserves its physical properties. At the next stage decomposition is followed by redefinition that brings the volume back to its initial condition re-establishing its physical identity. As opposed to the other houses where the physical demarcation of the block is constantly preserved, in this house there is an alternating loss and re-establishment of the identity and recognisability of the initial solid.

- **Geometrical properties**

At stage two the BF axis of the block organises symmetrical relations among all individual components and their defining lines, (TBH3 3.2, TBH3 3.3, fig. 2, p. 173). Thus, at this stage the shape geometrical properties coincide with the grid geometrical properties.

The LR axis controls also the positioning of certain elements. However, it organises relations of a local scale as opposed to the BF axis that divides the volume as a whole into two equal halves.

At stages three and four symmetry of the shape properties is broken by the introduction of the top and bottom voids, (TBH3 3.2, TBH3 3.3, fig. 10, 4, p. 173). However, at stage three the geometrical grids of the volume as a whole are 'just about' symmetrical with respect to the BF axis, (TBH3 3.3, fig. 31, p. 173). A dissociation between the shape geometrical properties and the grid geometrical properties is created that demonstrates that symmetry on the level of the shape geometrical properties is substituted by a subtler symmetry which needs the extension of the geometrical lines to be detected. At stage four overall symmetry of the grids is broken again by the asymmetrical organisation of the first floor grid, (TBH3 3.3, fig. 5, 33, p. 173).

At stage five the central location of the circular opening at the front elevation translates the BF axis to a central vertical axis restoring the asymmetrical articulation of the volume behind the facade, (fig 3.7, p. 203).

At stage six a dissociation between the properties of the shapes and the properties of the grids takes place again at the second floor level, operating along a distinction between asymmetrical organisation of shapes and symmetrical organisation of grids, (TBH3 3.2, TBH3 3.3, fig. 20, p. 173). However, the asymmetrical organisation of the first floor grid disrupts a three dimensional integration of all grid lines along the BF axis, (TBH3 3.3, fig. 34, p. 173). Finally, at stage seven the pyramid added at the top of the vertical shaft reintroduces symmetry along the BF axis.

Thus, in this house an alternating preservation and negation of the geometrical properties of the block accommodating both symmetry and asymmetry takes place. At certain stages asymmetry on the level of the shape properties is contrasted by symmetry on the level of the grid properties. Nevertheless, overall symmetrical organisation of the grids is not restored. This lack of overall symmetry seems to be compensated by the symmetrical treatment of the front facade that extending in front of the terraces conceals the asymmetrical organisation of the house.

- **H O U S E  A T  S T A B B I O - ( B H 4)**

- **GENERAL DESCRIPTION, (illustrations 3.26-3.29, p. 170)**

This house sits on a flat land in a recently subdivided area at the edges of a village. It is a cylindrical block that like the other houses of Botta integrates three horizontal levels around a vertical void, (illustration 3.26, p. 170).

This void slices the top of the volume into two equivalent halves opening up towards the base, (illustrations 3.26, 3.27a, 3.29b, p. 170). The axis of symmetry is emphasised by the glazed skylight at the top of the building and by a narrow slot that ends at a rectangular opening at the front face of the house.

At the opposite side a large cylindrical element assuming the form of a column accommodates the staircase and intensifies the back to front axis, (illustration 3.27b, 3.29a, p. 170). It is contained within the perimeter of the volume and is separated from its round surfaces by two glazed areas which gradually widen towards the ground. A lateral axis is introduced by two openings at the west side of the building. These openings are connected by an horizontal slot that detaches the top horizontal plane from the vertical surfaces of the house, (illustration 3.27a, p. 170). This gap emphasises the round cornice constructed by the obliquely layered course of concrete bricks that surrounds the volume at the top.

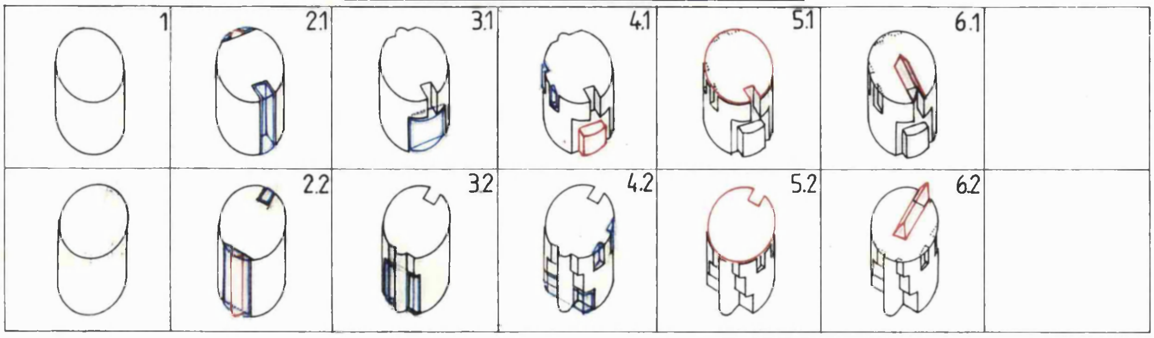
The various activities are developed in four floors and they are planned around the vertical void. The mechanicals and a recreation space are located at the basement, (illustration 3.28, p. 170). The ground floor contains the entry and the service areas. The first floor houses the day activities opening towards a terrace at the front. Finally, the second floor accommodates the bedrooms on the left and right sides of the void and the bathrooms on either side of the stairway drum at the back of the house.

- **DESCRIPTION OF STAGES**

At stage one the house is described by a cylindrical volume, (TBH4 3.1, fig. 1, p. 473). This volume is symmetrical with respect to any axis passing from its geometrical centre, (TBH4 3.2, fig. 1, p. 174).

At stage two a curvilinear volumetric unit is subtracted from the cylinder. A void is created that extends throughout the height of the volume, (TBH4 3.1, fig. 2.1, p. 473). Further, another curvilinear element is subtracted from the opposite side. A second void is defined that also covers the height of the volume as a whole (TBH4 3.1, fig. 2.2, p. 473). Inside this void a curvilinear volumetric unit is inserted extending also from the bottom to the top of the composition.

Table **BH4 3.1**



The geometrical centres of the two voids, of the curvilinear element and of the cylinder are located on the same axis, (TBH4 3.2, fig. 2, p. 174). The extensions of the lines that define the vertical shaft, the lines that are tangent to the curvilinear unit and the lines that start from the points of intersection of the straight surface of the back void with the cylinder define a geometrical grid, (TBH4 3.3, fig. 2, p. 174). From left to right the grid bays are arranged according to the following sequence: C B A B C. Thus, the grid is symmetrical with respect to a single axis and tripartite with respect to the central geometrical bay.

From back - to - front there is no such pattern like symmetry or tripartition. Thus, from all the axes passing from the centre of the cylinder a single axis is distinguished. The volume becomes directional pointing along the back to front direction.

At stage three a volumetric unit is subtracted from the front of the volume covering the ground and the first floor, (TBH4 3.1, fig. 3.1). At the back two equal in size and shape curvilinear units are subtracted from the right and left side of the semicylinder extending from the ground to the second floor, (TB4 3.1, fig. 3.2).

The geometrical centre of the new void is located on the BF axis (TBH4 3.2, fig. 3, p. 174)[11]. From left to right the grid bays are arranged according to the following rhythm: E F D A D F E, (TBH4 3.3, fig. 3, p. 174). Thus, the new lines and the new bays are organised again by symmetry and tripartition with respect to the BF axis and the central geometrical bay. From back to front the geometrical bays do not enter into symmetrical and tripartite relations.

The superimposition of all sections is also symmetrical along the BF axis, (TBH4 3.2, fig. 27). The grid bays are organised from left to right according to the following sequence: E F F B A B F F E, (TBH4 3.3, fig. 27). Thus, the volume is symmetrical as a whole with respect to the BF axis. At width the elements of the grid are not characterised by symmetry and tripartition.

At stage four two volumetric units are removed from the left side of the volume extending from the second floor to the roof, (TBH4 3.1, fig. 4.1). Two volumetric elements are also subtracted from the left and right side of the semicylinder stretching from the ground to the first floor, (TBH4 3.1, fig. 4.2). Finally, a volumetric unit is inserted inside the front void extending also from the base to the first floor. The front surface of this unit becomes part of the perimeter of the cylinder, (TBH4 3.1, fig. 4.1).

At the ground and first floor sections the geometrical centre of the volumetric unit added inside the front void is located on the BF axis, (TBH4 3.2, fig. 4, p. 174). The defining lines of this element coincide

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11 The third floor section and the roof plan remain as they are defined at stage two, TBH4 3.2, fig 2, p. 174). The ground and first floor sections are similar to each other, (TBH4 3.2, fig 3, 9, p. 174). So, analysis looks only at one of these sections.

with the lines that are defined by the back void at stage two, (TBH4 3.3, fig 4, p. 174). Further, the lines generated by the back voids introduced at this stage coincide with the lines generated by the front void defined also at stage three. From left to right the grid bays are arranged according to the following sequence: E B B A B B E. Thus, at lenght the grid is symmetrical and tripartite.

From back to front the geometrical grid progresses as following: E G E. This arrangement is tripartite along a central geometrical bay. However, symmetry of the grid as a whole operates only along the BF axis because the curve at the back of the building has no equivalent element at the front.

At the first floor section the bays are arranged from left to right according to the E F F B A B F F E rhythm, (TBH4 3.3, fig. 10, p. 174). Thus, symmetry and tripartition is employed at the organisation of this grid also. From back to front the grid bays do not enter into symmetrical and tripartite relations.

At the second floor section the voids at the left side have no equivalent elements at the right side of the cylinder, (TBH4 3.2, fig. 16, p. 174). Thus, at this stage the symmetrical organisation of shapes along the BF axis is broken by the introduction of these elements. From left to right the geometrical bays progress according to the ratio: I H B A B C, (TBH4 3.3, fig. 16, p. 174). It turns out that the new vertical line introduced by the side voids breaks also the symmetrical and tripartite organisation of the second floor achieved at stage two.

From back to front the geometrical bays progress according to the following rhythm: I H B A B D E. Thus, there is no symmetry or tripartition along this direction either. However, the lines of the side voids are symmetrical to each other with respect to the LR axis.

Looking at the superimposition of all sections it turns out that the lack of equivalent voids at the right side of the volume breaks overall symmetry of shape properties on the level of the building as a whole, (TBH4 3.2, fig 28, p. 174). The superimposition of all grids consists from left to right of ten geometrical bays that are arranged according to the sequence: I J F F B A B F F E, (TBH4 3.3, fig 28, p. 174). If the line defining the side voids at the second floor is omitted, the sequence becomes: E F F B A B F F E and symmetry and tripartition are introduced again in the configuration. From back to front the geometrical bays do not enter into symmetrical and tripartite relations.

At stage five the roof of the cylinder is extended over the side and the back voids, (TBH4 3.1, fig. 5, p. 473). There are no changes introduced to the geometrical properties of the ground, first and second floor sections. It is only the roof plan that changes returning back to the condition of stage two, (TBH4 3.2, TBH4 3.3, fig. 3, 23, p. 174). Thus, it is symmetrical and tripartite along the BF axis of the block.

At stage six a glazed triangular prism is added at the top of the front void, (TBH4 3.1, fig. 6.1, 6.2, p. 473). The geometrical centre of this element lies on the BF axis, (TBH4 3.2, fig. 24, p. 174). Besides, the left and right lines of this element coincide with the left and right lines of the void introducing no new lines to the geometrical grid, (TBH4 3.3, fig. 24, p. 174). Therefore, the properties of the grids at this stage are similar to the properties described at stage five.

- **COMPARISON ACROSS STAGES**

- **Physical properties of the block**

Similarly to the houses examined before the transformations changing the volume are subtraction, addition and planar extension. Subtraction at stage two excavates the block at the front and the back without destroying the cylindrical shape of the initial solid. The physical identity of the initial volume is, thus, retained, (TBH4 3.1, fig. 2, p. 473).

At stage three subtraction widens the voids reducing the physical definition of the cylinder towards the base. However, the top of the volume remains as it is defined at stage two. The cylinder can still be recognised and understood as the origin of the configuration, (TBH4 3.1, fig. 3, p. 473).

At stage four the physical definition of the initial solid is reduced further, by the removal of volumetric components from the back and from the sides of the volume, (TBH4 3.1, fig. 4, p. 473). However, the addition of a curvilinear element restores the front surface strengthening the physical demarcation of the initial solid.

The extension of the roof at stage five restores the top circular edge of the cylinder, (TBH4 3.1, fig. 5, p. 473). The plane of the roof creates a circular cornice at the top of the volume manifesting the roundness of the form and intensifying the physical definition of the cylinder.

At stage six the addition of a triangular prism over the front void does not affect the physical appearance of the cylinder, (TBH4 3.1, fig. 6, p. 473). The prism strengthens the role of the front void. The hierarchical order of the second stage is, thus, emphasised.

Thus, at every stage the transformation of the volume preserves the physical properties of the cylinder. Elements are subtracted and added to the configuration in a way that the initial solid is recognisable as the overall geometrical concept in the arrangement.

- **Geometrical properties**

The BF axis of the cylinder constrains the placing of the elements in every stage governing both levels of geometrical properties, their properties as shapes and their properties as grid lines. The application of the same rule in all stages strengthens the power of the axis by gradually accumulating elements under its organising role.

However, the control this axis has over the organisation of the volume as a whole is broken by the introduction of the side voids at stage four. Nevertheless, symmetry is suspended at the later stages of the transformation process by the small scale articulation. Thus, the BF axis retains its organising strength articulating symmetrical relations among the larger scale components. Besides, symmetry is reinforced on the level of the geometrical grids that are 'just about' symmetrical.

Whereas the BF axis controls constantly the combinations of the subtracted and the added elements, the LR axis is introduced only at the fourth stage. Thus, the strength of the BF axis is systematically increased, while the strength of the LR axis is developed to a much lesser extent. Besides, the tripartite relations at length appear also stronger than those operating at width of the configuration.

Thus, a systematic strengthening of the geometrical properties of the first stage is built based on a constant application of symmetry along the BF axis of the cylinder. At the same time the preservation of the physical identity of this cylinder throughout the analytic stages creates an increased intensification of the initial solid.

- # L E C O R B U S I E R

- ## V I L L A S A V O I E - ( L H 2 ).

- ## GENERAL DESCRIPTION, (illustrations 3.34-3.37, p. 194)

Located at the centre of a small meadow, surrounded by trees and elevated on pilotis this villa incorporates Le Corbusier's vocabulary and compositional principles, featuring free facades, free plans, ribbon windows and a roof garden, (illustration 3.34, p. 194). Like Villa Stein it is the latest of a series of design proposals which experimented on the principles of the Do-mino structure, on the five points, on the vertical tripartite arrangement of the volume and on the 'promenade architecturalle'.

The house is organised into three horizontal layers that are clearly distinguished from one another. A middle layer, pierced by ribbon windows along its periphery and crowned by a roof structure of curved walls, floats above a setback ground floor. The curved shape of the ground floor determined by the turning radius of a car, contrasts the rectangular volume of the first floor. This volume is also set in contrast with the curved screens crowning the building at the top.

The visitor approaches the house from the back and has to turn 180 degrees to find the entry situated on the back to front axis. On the ground floor are the entrance hall, the garage, utility rooms and the servants quarters. An elongated ramp ascends from the entry hall to the first floor, (illustration 3.36a, p. 194). The living activities are found on this floor arranged along the periphery and around a terrace garden enclosed within the external surfaces of the house, (illustration 3.35a, p. 194).

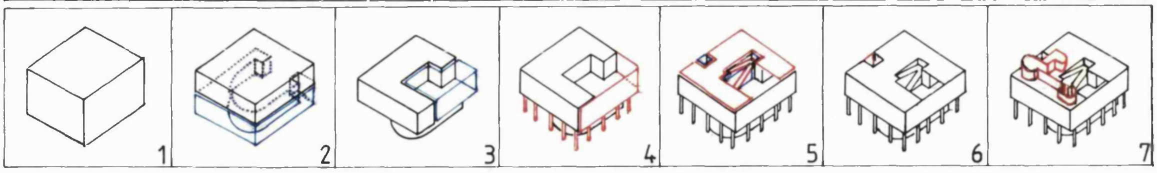
The procession of the ramp terminates at the roof terrace exemplifying the promenade architectural and encouraging an experience of the house built through movement and exploration. On his arrival to this terrace the visitor faces the curved walls, set perpendicular to the axis of movement, remnants of previous design solution that located madame Savoie's bedroom on the roof, (illustration 3.37b, p. 194).

- ## D E S C R I P T I O N O F S T A G E S

At stage one the house is described by a rectangular volumetric block, (TLH2 3.1, fig. 1, p. 478). This block is symmetrical with respect to two perpendicular axes that pass through its geometrical centre, (TLH2 3.2, fig. 1, p. 198).

At stage two a volumetric unit is subtracted from the bottom of the block, (TLH2 3.1, fig. 2, p. 478). Its external surfaces define a rectangular U, while its internal surfaces define a curvilinear U. The block is

Table **LH2 3.1**



divided into two volumetric components. The top one is a rectangular, whereas the bottom one is a curvilinear volume.

The latter is symmetrical with respect to the BF axis of the block, (TLH2 3.2, fig. 2, p. 198). On the other hand, the former is symmetrical on both BF and LR axes, (TLH2 3.2, fig. 8, p. 198). Looking at both sections together it becomes apparent that the volume can be divided as a whole into two equivalent halves with respect to the BF axis of the block, (TLH2 3.2, fig. 20, p. 198).

The geometrical grid of the ground floor consists of five geometrical bays that are arranged at length according to the following rhythm: C B A B C, (TLH2 3.3, fig. 219). This is a symmetrical and tripartite arrangement along the BF axis and the central geometrical bay running from the back to the front of the configuration. Thus, the geometrical properties of the shapes at this stage coincide with the geometrical properties of the grids.

At stage three a volumetric L is subtracted from the rectangular volume, (TLH2 3.1, fig. 3). A volumetric U is created, one leg of which is shorter than the other. In plan this is an asymmetrical shape, (TLH2 3.2, fig. 9, p. 198). Thus, the configuration of the first floor section is not symmetrical along any of the axes of the block. The superimposition of the ground and the first floor sections creates a new arrangement that is not symmetrical on any axis either, (TLH2 3.2, fig. 21, p. 198). Thus, the volume is no longer symmetrical as a whole along the BF axis.

The geometrical grid of the first floor section consists of three geometrical bays at length that are arranged according to the rhythm: A D D, (TLH2 3.3, fig. 9, p. 199). There are no symmetrical and tripartite relations among these bays. At width the grid consists of three geometrical bays that are organised according to the following sequence: E A E. This arrangement is both symmetrical and tripartite along the LR axis of the block and the central geometrical bay extending from the left to the right of the house. Therefore, although the solid component is asymmetrical as a shape, it generates a symmetrical configuration of grid lines. Thus, a dissociation between the shape and the grid properties takes place at this stage.

The superimposition of the two grids consists of six geometrical bays at length that proceed according to the following rhythm: C B D D B C, (TLH2 3.3, fig. 21, p. 199). Thus, the grid is bilaterally symmetrical with respect to the BF axis of the block. It is also tripartite with respect to two central geometrical bays resulting from the division of the central geometrical bay of the ground floor grid of stage two into two zones, (TLH2 3.3, fig. 2, p. 199).

At width this grid consists of five geometrical bays that are arranged according to the rhythm: F D A E. It turns out that symmetry and tripartition do not operate along the back to front direction. Thus, the grid of the building as a whole is symmetrical and tripartite only along the left to right direction.

At stage four the right and back surfaces of the first floor volume are extended to define the rectangular volume created at stage two, (TLH2 3.1, fig. 4, p. 478). Three rows of cylindrical support elements surrounding the curvilinear element are also added at the ground floor. At width they are tangent to the outer surface of the first floor volume. At length they are placed along the front side and they are set slightly back from the perimeter of the volume.

The extension of the surfaces does not produce any change to the shape and the grid geometrical properties of each horizontal section, (TLH2 3.2, p. 198, TLH2 3.3, fig. 4, 10, 16, p. 199). Thus, these properties remain as they are defined at the previous stage.

If the addition of the support elements is taken into consideration then a grid is generated constructed by the vertical and horizontal lines connecting the centres of the columns. This grid consists of regular geometrical intervals, (TLH2 3.4, fig. 1, p. 199) and is symmetrical with respect to two of its lines passing from the geometrical centre of the block[12].

When the structural grid and the physical grid[13] of the ground floor are superimposed, (TLH2 3.4, fig 1, p. 199), they merge at length into the same symmetrical and tripartite pattern with the one constructed by the superimposition of the physical grids of all floors, i.e. : C B D D B C, (TLH2 3.3, fig. 22, p. 199). From back to front the geometrical bays proceed according to the sequence: F D D D D F. Although this is a tripartite arrangement the equal spacing of geometrical intervals located in between the two narrow geometrical bays makes this configuration to register as a repetitive pattern of equal geometric units rather than as a hierarchical distinction between two side bays and a set of central bays.

When the structural grid and the physical grid of the first floor are superimposed the sequence of the bays at length coincides with the D D D D sequence of the structural bays. At width the sequence progresses according to the pattern: F D D D D F, (TLH2 3.4, fig. 4, p. 199). Thus, the tripartite organisation of the first floor physical grid, (E A E, TLH2 3.3, fig. 10, p. 199), is combined with the homogenised organisation of the structural grid in a way that the two patterns although fundamentally different in principle they merge into an harmonious relationship[14].

At stage five a volumetric L is subtracted from the first floor volume, (TLH2 3.1, fig. 5, p. 478). A rectilinear ramp is added inside the void that is created by the subtraction of this component. Further, a

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12 The structural grid is examined only in cases like this house where it participates in the articulation of their external appearance.

13 The grid that is generated by the physical elements.

14 The combination of the structural grid with the physical grids of all floors is not examined because it results in a grid that is identical to the ones examined before in fig. 1, 4, of TLH2 4.4, (p. 199).

volumetric rectangle is subtracted from the left side of the same volume. Finally, a part of the surface of the roof is extended towards the left and over the void to reach the outer surfaces of the composition.

At this stage the articulation of the ground floor remains as it is defined at the previous stages[15]. The volumetric L subtracted from the first floor is not a symmetrical element, (TLH2 3.2, fig. 11, p. 198). Besides, the central axes of the left void do not coincide with any of the axes of the block. On the other hand the geometrical centre of the ramp is located on the LR axis. However, there is no overall symmetry regarding the organisation of this floor section as a whole. There is not any symmetrical pattern governing the organisation of the superimposition of all sections either, (TLH2 3.2, fig. 23, p. 198).

The physical grid of the first floor consists of six geometrical bays at length and seven bays at width. At length the geometrical bays are arranged according to the sequence: C D F F G D, (TLH2 3.3, fig. 11, p. 199). These bays are not related by any symmetrical or tripartite rule to one another. At width the bays proceed according to the ratio: G J E H B E. Thus, the symmetrical and tripartite arrangement of the first floor grid observed at the previous stages, (TLH2 3.3, fig. 9, 10, p. 199), is broken at this stage.

Looking at the superimposition of all grids it turns out that from left to right the arrangement of the grid bays progress according to the C B G F F G B C rhythm, (TLH2 3.3, fig. 23, p. 199). *Thus, although the grid of the first floor is asymmetrical the combination of the two grids results into a symmetrical and tripartite arrangement.* From back to front the order of the bays is as follows: F J J E H B There is still no symmetrical or tripartite relations among the grid bays.

When the structural grid is superimposed on the physical grid of the first floor the sequence of the bays from left to right proceeds as follows: C B G F F G D, (TLH2 3.4, fig. 5, p. 199). This is not a symmetrical or tripartite pattern. From back to front the sequences follow the ratio: F J J D B H B D F. This sequence is not ruled by symmetry or tripartition either[16].

At stage six the left vertical surface of the first floor volume is extended in front of the left void joining the two planes created by the subtraction of a volumetric rectangle at stage five into a single surface. Besides, a volumetric L and a series of straight and curved walls forming a continuous screen are added at the roof, (TLH2 3.1, fig. 6, p. 158).

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15 The ramp features in both ground and to the first floor plans. It is only at the first floor, though that it functions as an element of the external articulation. Thus, at this stage the analysis looks at the changes introduced by the ramp only in relation to the first floor.

16 The superimposition of the structural grid with the physical grid of all horizontal sections, (TLH2 3.4, fig. 11), is not discussed because it is similar to the one examined by fig 5 in TLH2 3.4.

The volumetric L is not a symmetrical element. Further, its position is not related to any of the axes passing from the geometrical centres of other elements, (TLH2 3.3, fig. 18, p. 199). The screen structure does not form any closed shape. So, analysis cannot look at its geometrical axes. Therefore, the organisation of the roof plan is not governed by symmetry as a whole.

Looking at the layers of all sections it turns out that there is no overall symmetry operating on the level of the building as a whole, (TLH2 3.3, fig. 24, p. 199).

The roof plan grid coincides with the grid defined by the superimposition of the first floor physical grid and the structural grid at the previous stage, (TLH2 3.3, fig. 18, p. 199). Thus, it is not symmetrical and tripartite along any direction.

The superimposition of the grids of all plans results in a new grid that at length is organised as following: C B G F F G B C, (TLH2 3.3, fig. 24, p. 199). Thus, from left to right the geometrical grids of the building as a whole are symmetrical with respect to the BF axis and tripartite in relation to the central geometrical bay. From back to front the geometrical grids are organised according to the following pattern: F J J I F H B L K. Thus, along this direction there is no symmetrical or tripartite rule governing the disposition of the geometrical bays.

The combination of the physical grid of the roof terrace and the structural grid produces an arrangement that from left to right is organised as following: C B G F F G D, (TLH2 3.4, fig. 9, p. 199). At length the arrangement of the bays is as follows: F J J D H F H B D H F. There is no symmetry or tripartition operating in any of the two directions.

The superimposition of the physical grids of all sections and the structural grid results in a configuration that from left to right is similar to the one described by the superimposition of the physical grids and the structural grid at the previous stage, (TLH2 3.4, fig. 10, p. 199). From back to front the arrangement of the grid bays is: F J J D H F H B D H F. Thus, these bays do not enter into symmetrical and tripartite relations.

- **COMPARISON ACROSS STAGES**

- **Physical properties**

Similarly to the house examined before this house results from a series of transformations that are based on the operations of subtraction, addition and planar extension. Subtraction at stage two divides the block into two clearly distinguishable volumetric components. It also destroys the physical definition of its four bottom vertexes, of half of each vertical edge and half of each vertical surface, (TLH2 3.1, fig. 2, p. 478). Thus, the block is no longer present as a physical entity.

At stage three subtraction decomposes the volume further destroying the physical definition of the top right vertex at the back and reducing the physical definition of the vertical left and back surfaces, (TLH2 3.1, fig. 2, 3, p. 478). Thus, at stages two and three the physical definition of the initial solid is not preserved.

The extension of the surfaces of the first floor volume and the addition of the columns at the ground floor at stage four attempts to redefine the block, (TLH2 3.1, fig. 4, p. 478). Planar extension restores the physical definition of the vertical right edge at the back of the first floor volume. The extension of the roof plane over the open space at stage five restores also the back right vertex, and the back horizontal edge of this volume, (TLH2 3.1, fig. 5, p. 478).

At the ground floor the cylindrical columns provide only with an implicit physical definition of the outline of the initial solid. Thus, unlike LH1 where planar extension aims at redefining the block, at this house it restores the rectangular volume resulting from subtraction at stage two. Thus, it emphases the horizontal division of the initial solid into two volumetric components.

The extension of the surfaces defines also the first floor terrace. In this respect, the block, the rectangular volume, the volumetric U and the void are defined by common boundaries. However, it is not only the external surfaces that these elements share. The volumetric U and the open space interpenetrate in a way that the internal surfaces of the former give definition to the latter.

These elements interlock joined together by a mutual interconnection of parts, (fig 3.16, 3.17, p. 203). It seems that the interlock relation between the two voids occurring in LH1 in section, (fig 3.15, p. 203), is transferred in this house to the plan. Thus, there seems to be a design logic that excavates and subdivides the volumes in a way that a series of interpenetrating Ls is created that are firmly fastened together.

Subtraction at stage five changes the internal sides of the volumetric U, (TLH2 3.1, fig. 5, p. 478). The complexity of this shape is, thus, increased further. The excavation of the U expands the area of the open space that twists, penetrates and erodes the surfaces of the closed volume. Interpenetration and mutual definition of shapes is, thus, exaggerated by the creation of a geometrical pattern similar to the 'maiandrus' pattern, (fig. 3.18, p. 203).

Thus, whereas from the exterior the first floor volume looks as one simple volumetric object, in the interior it consists of two complex interpenetrating elements that complement each other. Therefore, on the one hand transformation simplifies the external complexities of the volume created by subtraction at stage three. On the other it complicates its internal articulation resulting in a strong differentiation between a simple exterior and an elaborate interior. The simplicity of the exterior is contrasted further by the introduction of the free arrangement of the curved surfaces at the top of the rectangular volume. These surfaces introduce a third layer of elements intensifying even more the horizontal division of the volume into separate layers.

Thus, two types of transformations can be identified from this analysis. One decomposes and subdivides horizontally the block into volumetric constituents that do no longer sustain its physical properties. The other adapts these constituents to accord with the physical description of the solids of the first stages. Negation and preservation of the physical definition of these solids alternate in a way that at one state the volume is not related to the initial objects and at another state it refers directly to them.

Besides, planar extension reinstates the volumetric rectangle decomposing the external articulation of the volumetric U. Thus, these components and the garden terrace bound together by the same surfaces become interdependent in a way that definition of the one is achieved by the decomposition of the other. Further, the interlocking relationship of the solid and the void elements destroys also the volumetric clarity of their internal articulation.

- **Geometrical properties**

At stage two the volume is symmetrical as a whole with respect to the BF axis of the block, (TLH2 3.2, fig. 20, p. 198). Nevertheless, overall symmetry along the BF axis is contrasted by the symmetrical organisation of the first floor volume along both BF and LR axes.

At the following stages overall symmetry is broken by the asymmetrical organisation of the first floor, (TLH2 3.2, fig. 21-24, p. 198). Thus, symmetry in terms of the shape geometrical properties on the scale of the volume as a whole is restricted at the first two stages. However, the ground floor remains symmetrical along the BF axis throughout the transformation process, (TLH2 3.2, fig. 2-6, p. 198). Thus, an horizontal division of the volume into separate geometrical systems is articulated expressed by an opposition between either symmetry of the ground floor along the BF axis and symmetry of the first floor along both axes, or between symmetry of the ground floor and asymmetry of the first floor.

Analysis of the geometrical properties of the grids points out that the superimposition of the physical grids results in an arrangement that is symmetrical and tripartite from left to right in every analytic stage, (TLH2 3.3, fig 20-24, p. 199). However, whereas the ground floor grid is constantly symmetrical and tripartite from left to right, (TLH2 3.3, fig 2-6, p. 199), the first floor and the roof plan grid are symmetrical from back to front at stages three and four, (TLH2 3.3, fig. 9, 10, 15, 16, p. 199), and asymmetrical at stages five and six, (TLH2 3.3, fig 11, 12, 17, 18, p. 199).

Thus, whereas the grids of the individual levels can merge into a symmetrical pattern, they appear to differentiate themselves being either asymmetrical or symmetrical along another axis. In this respect the physical division of the volume into separate volumetric components becomes also a geometrical division into layers governed by different properties.

The superimposition of the structural grid and the physical grids of all floors creates a grid that is symmetrical along the BF axis and tripartite with respect to two central geometrical bays running from back to front, (TLH2 3.4, fig. 10 - 12, p. 199).

However, it is only the superimposition of the structural grid and the physical grid of the ground floor that is constantly symmetrical and tripartite from left to right, (TLH2 3.4, fig 1, 2, 3, p. 199). The superimposition of the structural grid and the physical grid of the first floor and the roof plan is found symmetrical at stage four along both directions, (TLH2 3.4, fig. 4, 7, p. 199), and asymmetrical at stages five and six, (TLH2 3.4, fig. 5, 6, 8, 9, p. 199).

Thus, similarly to the geometrical properties of the shapes and the geometrical properties of the physical grids, the properties of the superimposition of the structural and the physical grids operate along a contrast between overall symmetry with respect the BF axis and symmetry of particular floor levels with respect to both BF and LR axes or between overall symmetry and asymmetrical organisation of these levels.

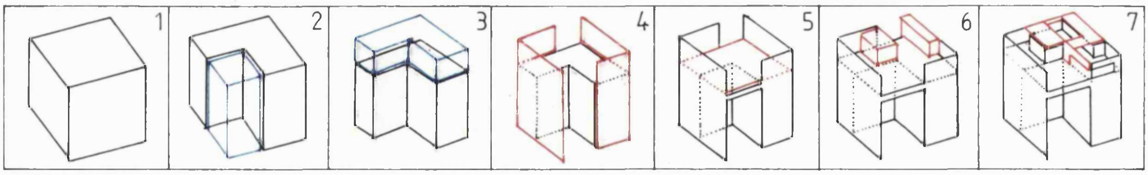
It turns out that the geometrical organisation of this house as a whole presents with the following characteristics:

- A dissociation between the shape and the grid geometrical properties. The former are characterised by symmetry only at the first stages, whereas the latter exhibit symmetry and tripartition throughout the analytic sequences. Thus, like LH1 this house negates an obvious organisation of the shape properties based on an overall symmetry adopting subtler 'hidden' symmetries of the regulating grids.

- A dissociation between geometrical properties of different horizontal layers. Although these levels are integrated on two dimensions by a single symmetrical and tripartite pattern a three dimensional integration of them around this pattern is disturbed.

- The dissociation created between the two level of properties and between the individual layers shows that there is not a single geometrical rule that is employed from the beginning to the end, from the largest to the smallest elements and from the scale of each floor to the scale of the building as a whole. Thus, the house from a first point of view looks asymmetrical. A second examination reveals that the asymmetrical appearance is transformed into a carefully planned symmetry based on a multilayered organising network of grid elements. However, although levels are synchronised under a single rule, decipherment of the overall symmetry and tripartition is arrested either by the asymmetrical and non tripartite treatment of a floor level or by its symmetrical and tripartite organisation along another axis and another geometrical bay.

Table **LH3 3.1**



- VILLA MEYER- (LH3)

- **GENERAL DESCRIPTION, (illustrations 3.38-3.41, p. 195)**

Like the other early villas of Le Corbusier this house comprises the five points and the idea of a 'promenade architectural' that leads the visitor from the street level to the living rooms of the upper floors, (illustration 3.38, p. 195).

A deep terrace garden at the front extends from the ground to the suspended structure of the roof terrace. At the back the house presents with a flat facade pierced throughout its length by ribbon windows, (illustration 3.42, p. 195). The two sides are solid consisting of vertical planes that flank the volume and orient it towards the back to front axis.

One enters the house through the garden terrace that like a loggia set off axis leads to the ground floor, (illustration 3.40b, p. 195). Entry is set at ninety degrees to the BF axis of the house and opens directly into the sitting room. From the ground floor the visitor ascends to the floor above taking the elongated ramp that is situated at the right top corner of the plan or one of the staircases found near the front facing surface of the terrace.

The house is developed into three levels. The basement houses the service facilities, (illustration 3.40a, p. 195), the ground floor accommodates the day activities, (illustration 3.40b, p. 195), and the first floor holds the bedrooms, (illustration 3.40c, p. 195). Special emphasis is put on the roof garden to express the spirit of a luxury life that comprises a breakfast room indoors or outside in the terrace, a suspended swimming pool, a covered terrace, a solarium and a screened off area for with an open air shower, (illustration 3.41, p. 195).

- **DESCRIPTION OF STAGES**

At **stage one** the house is described by a cube, (TLH3 3.1, fig. 1, p. 486). This cube is covered by a vertical, a horizontal and two diagonal axes passing through its geometrical centre, (TLH3 3.2, fig. 1, p. 466).

At **stage two** a rectangular volumetric unit is subtracted from the block, (TLH3 3.1, fig. 1, p. 486). The resulting volume is a volumetric L.

All the horizontal sections through this volume consist of a planar L and a square, (TLH3 3.2, fig. 2, 9, 16, 23, p. 200). Both these shapes are symmetrical with respect to the diagonal axis of the block running from the left front to the back right vertex.

The geometrical grid of these sections consists of two geometrical bays at length and two geometrical bays at width, (TLH3 3.3, fig. 2, p. 200). There are no patterns of symmetry or tripartition operating from left to right and from back to front. However, the geometrical bays enter into relations of geometrical symmetry along the diagonal axis.

At stage three a volumetric L is subtracted from the top of the volume, (TLH3 3.1, fig. 3). The geometrical properties of all horizontal sections are similar to those of stage two, (TLH3 3.2, p. 200, TLH3 3.3, p. 200).

At **stage four** the right and left surfaces of the volumetric L are extended towards the top and the front to reach the edges of the initial solid, (TLH3 3.1, fig. 4). The front surface and a part of the back surface of the volumetric L are also extended to reach the top of the block. At this stage there are no changes introduced at the geometrical structure of the volume, (TLH3 3.2, TLH3 3.3, p. 200).

At **stage five** the top horizontal surface of the volumetric L is extended towards the front and the left to reach the front and the left vertical planes of the volume[17], (TLH3 3.1, fig. 5). At this stage also the geometrical properties remain as they are defined at stage two, (TLH3 3.2, TLH3 3.3, p. 200).

At stage six two volumetric components are added at the roof terrace, (TLH3 3.1, fig. 6). One is a rectilinear volumetric unit that is attached at the right surface of the volume. The other is a rectangular unit the front side of which forms an extension to the front facing side of the void.

At this stage analysis examines only the horizontal section cutting through the third floor, (TLH3 3.2, fig. 20, p. 200). The axes passing from the geometrical centres of the two new elements are not symmetrical with respect to any of the axes of the block. Thus, the geometrical organisation of this section does not correspond to the geometrical organisation of the initial volume.

The geometrical lines that these components generate introduce four geometrical bays at length and four bays at width, (TLH3 3.3, fig. 20, p. 200). The rhythm of the bays at length is : A A A D. At width the bays are arranged as following: D F E C. Both these patterns are not characterised by symmetry and tripartition.

At **stage seven** the roof of the rectangular volumetric component is extended towards the back to intersect with the back vertical surface of the volume, (TLH3 3.1, fig. 7). The roof of the rectilinear component is also extended towards the left in the shape of a planar L. The left facing surface of the void is extended towards the top in the form of a planar L to intersect with the top surface of the curvilinear

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17 This plane defines the roof terrace of the house.

element and with the front plane of the volume. Vertical linear elements transform this plane into a screening device that divides the roof terrace into the area of the swimming pool at the left and a second terrace at the right.

The roof plan seen as a configuration of shapes is not governed by symmetry as a whole with respect to any axis, (TLH3 3.2, fig. 28, p. 200). The geometrical grid of this plan consists of three geometrical bays at width that progress according to the following rhythm: C E C, (TLH3 3.3, fig. 28, p. 200). Thus, symmetry and tripartition is introduced along the LR axis of the block. At length the grid bays are organised as previously i.e.: A A A D. Thus, symmetry and tripartition operates only at width of the configuration.

The superimposition of all sections consists of four bays at width and three bays at length. The organisation of this grid coincide with the organisation of the grid at stage six. The bays from left to right are arranged according to the sequence: A A A D. From back to front they are organised as following: D F E C, (TLH3 3.3, fig. 35, p. 200). Thus, the grids of the building as a whole are not organised according to symmetry and tripartition in any direction.

- **COMPARISON ACROSS STAGES**

- **Physical properties**

The operations transforming the volume are subtraction, addition and planar extension. At stage two the top and bottom vertexes at the left as well as the left vertical edge of the block loose their physical definition, (TLH3 3.1, fig. 1, 486). Besides, the physical definition of its front, its left and its top surfaces is reduced. Like LH1 and LH2, subtraction decomposes the block destroying its identity and recognizability as a physical object. This decomposition continuous at stage three with the subtraction of a volumetric L from the top of the volume, (TLH3 3.1, fig. 3, p. 486). In this case all four vertexes and all four horizontal edges of the block at the top become physically undefined.

The extension of the left and the right planes of the volume at stage four redefine the outer surfaces of the block, (TLH3 3.1, fig. 4, p. 486). These planes redefine also the voids created by the subtraction of a volumetric rectangle and of a volumetric L at stages two and three respectively. However, full physical definition is not given to the vertexes of both the volumetric L and the block. The extended surfaces are read as planes so that the two volumes achieve both volumetric and planar readings[18]. Like LH1 and LH2 the definition of these elements by common surfaces creates an interdependence among them in a way that the definition of the one requires the decomposition of the other.

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18 An object gives volumetric readings when each of its surfaces intersects with two other surfaces in a way that it has only one face. An object gives planar readings when some or all of its surfaces extend beyond the intersection lines having, thus, two faces.

At stage six the addition of the two volumetric components does not change the physical definition of the volume, (TLH3 3.1, fig. 6, p. 486). However, like in LH2 the solid and the void components interlock and clasp together joint firmly by a mutual definition of parts, (fig. 3.19, 3.20, p. 203).

At stage seven the planar extension of the roof of the two volumetric elements and the extension of the side facing surface of the garden terrace provide with partial physical definition of the block and the volumetric L that is subtracted at stage three. However, the extended planes do not restore completely the volumetric definition of these solids. Besides, they transforms the solid elements into a combination of volumetric and planar parts destroying their volumetric clarity.

The transformation of the volume, thus, starts by a decomposition of the initial solid into volumetric components that no longer carry its physical characteristics. This decomposition is followed by a restoration of the removed parts that does not complete the physical description of the block providing with volumetric and planar characteristics to all the components. A mutual definition of solids and voids results from this process that interconnects the various elements into a configuration that registers towards all possible readings never achieving a clear classification of the elements into distinct volumetric concepts.

- **Geometrical properties.**

At stages two, three, four and five the volume is symmetrical as a whole in both levels of properties with respect to the diagonal axis of the block, (TLH3 3.2, p. 200, TLH3 3.3, fig. 2, 3, 4, 5, p. 200). Thus, the geometrical properties of the shapes coincide with the geometrical properties of the grids, (TLH3 3.3, fig 2, 3, 4, 5, p. 200).

At stage six the second floor section is asymmetrical in terms of both levels of properties, (TLH3 3.2, TLH3 3.3, fig. 20, p. 200). Thus, symmetry of the volume as a whole along the diagonal axis created at the previous stages is broken by the asymmetrical arrangement of the top of the house.

At stage seven symmetry and tripartition are introduced at the grid of the roof plan operating at length of the configuration, (TLH3 3.3, fig. 28, p. 200). However, the organisation of the grids of the house as a whole is not governed by these principles, (TLH3 3.3, fig. 35, p. 200).

It turns out that at this house symmetry on the global level is limited at the first five stages. At the last two stages it is broken by the asymmetrical organisation of the second floor. At these stages the asymmetrical treatment of the grids on the level of the global scale is contradicted by the symmetrical treatment of the ground and first floors along the diagonal as well as with the symmetrical treatment of the roof plan along the LR axis.

Thus, like in LH1 and LH2 the volume is divided horizontally into floor layers each of which exhibits a different organising principle. The understanding of the geometrical organisation of this house, thus, becomes a matter of a long and persistent investigation in which the classification of systems along one direction is contradicted by their groupings around a different one.

- ## VILLA BAIZEAU- (LH4)

- ## GENERAL DESCRIPTION, (illustrations 3.42-3.45, p. 196)

The first design for Villa Baizeau demonstrates in the clearest possible way the principles of the Domino frame as an independent supporting structure, (illustration 3.42, p. 196). This frame is completely visible from the front spanning four storeys and supporting a large canopy at the top of the house. A recessed ground floor exposes the columns at the base raising a part of the house from the ground.

The sides and the back of the building are closed by non structural surfaces. The front side becomes, thus, its only public face. An intrinsic characteristic of this face is its complete exposure in section to the outside. The vertical relationship between the four levels is revealed as a sectional concept of alternating spaces of double height. Their interlock relationship defines secondary spaces having the height of a single floor.

The pilotis articulates access to the house through an entry that set slightly off axis leads to the entry hall, (illustration 3.44a, p. 196). Taking the stairs situated at ninety degrees to the axis of entry the visitor ascends to the upper floors. This stairs initially enclosed in the interior becomes flanked by terraces on the first floor, (illustration 3.44b, p. 196). Reaching the third floor it terminates at a linear gallery running along the back to front axis of the house facing the sitting room below and opening to a longitudinal terrace to the right, (illustration 3.44d, p. 196).

The ground floor houses the entry hall at the front and the service quarters at the back. The first floor and the front part of the second floor accommodate the living areas. At the bhe back of the second floor three bedrooms with their bathrooms are found. Finally the third floor contains a linear gallery extending from the centre of the plan to the front as well as three mezzanines facing the bedrooms below.

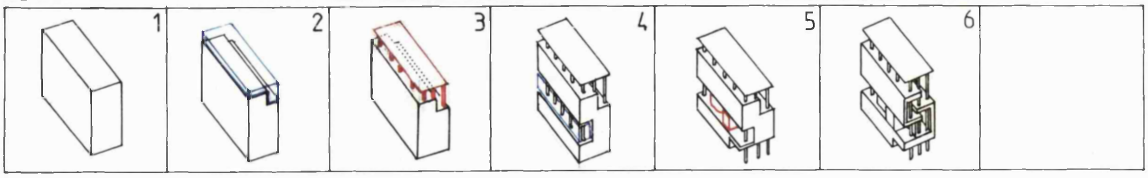
- ## DESCRIPTION OF STAGES

At stage one the house is described by a rectilinear volumetric element, (TLH4 3.1, fig. 1, p. 491). This element is covered by two perpendicular axes passing from its geometrical centre, (TLH4 3.2, fig. 1, p. 201).

At stage two a volumetric L that extends throughout the long side of the block is subtracted from its top, (TLH4 3.1, fig. 2, p. 491). The remaining volume is a volumetric L.

The third floor section consists of two rectangles that occupy the whole length of the volume, (TLH4 3.2, fig. 20, p. 201). The centres of both rectangles lie on the LR axis of the block. At width these

Table **LH4 3.1**



shapes are described by different axes. These axes are not symmetrical with respect to the BF axis of the block. The volume is thus, symmetrical as a whole only along the LR axis, (TLH4 3.2, fig. 20, p. 201).

At stage three a horizontal plane supported by a structural grid of twelve columns is added at the top of the volume, (TLH4 3.1, fig. 3). The new elements replace in size and position the subtracted volumetric L redefining its top horizontal surface.

The geometrical properties of the third floor section remain as they are defined at stage two, (TLH4 3.2, fig. 20, p. 201). The structural grid at length consists of two geometrical bays and a cantilever on either side, (TL4 3.4, fig. 8, p. 202). Along this direction the geometrical bays are arranged as following: B A A B. From back to front there are four geometrical bays that proceed according to a C C C C rhythm. The central lines of this grid at both directions coincide with the BF and the LR axes of the block.

If the structural grid and the grid of the third floor section are superimposed the arrangement of the new grid at length is as follows: B A B D B, (TLH4 3.4, fig. 20, p. 202). Thus, the superimposition of the two grids is not symmetrical or tripartite. At width the bays progress according to the C C C C pattern of the structural grid. Thus, from back to front symmetry is retained.

At stage four a rectilinear volumetric component extending throughout the length of the block is subtracted from the left side of the volume at the first floor exposing a row of vertical columns, (TLH4 3.1, fig. 4). A terrace is defined that divides the left side of the volume into four horizontal layers arranged according to an alternating rhythm of void and solid zones.

The first floor section consists of two longitudinal rectangles that are covered by the LR axis of the block, (TLH4 3.2, fig. 10, p. 201). The superimposition of all sections consists of three rectangles, (TLH4 3.2, fig. 28, p. 201). The axis pacing from the geometrical centre of the middle one coincides with the BF axis of the block. The axes of the two side rectangles enter into a symmetrical relationship with respect to the BF axis. Thus, overall symmetries are created among elements belonging to different floor levels. Besides, whereas the first and the third floor levels are symmetrical only with respect to the LR axis the organisation of the building as a whole is symmetrical along both axes.

The geometrical grid of the first floor section consists of two unequal geometrical bays at length, (TLH4 3.3, fig. 10, p. 202). There is no symmetry and tripartition in this arrangement. The superimposition of all sections results in a grid that is symmetrical and tripartite from left to right according to an A F A rhythm, (TLH4 3.2, fig. 28, p. 201). Thus, although the geometrical grid of the first and third floor are not characterised by symmetry and tripartition the grid of the building as a whole is symmetrical along the BF axis and tripartite with respect to the central geometrical bay running along the length of the building.

If the physical grid of the first floor is combined with the structural grid then the new grid consists at length of six geometrical bays that enter into a B D B A B relation, (TLH4 3.4, fig 10). Thus, symmetry and tripartition are not created along the left to right direction.

The superimposition of the structural grid and the grids of all floors results in a B D B B D B sequence of grid bays. Thus, from left to right the geometricl bays enter into symmetrical and tripartite relations, (TLH4 3.4, fig. 28, p. 202).

At stage five a volumetric L is subtracted from the ground floor, (TLH4 3.1, fig. 5, p. 491). The left, the right and the front sides of this volume are straight, whereas its back side form a continuous curved surface. A part of the volume is now elevated from the ground floor while the front row of columns is exposed forming a pilotis structure. Further, two volumetric components are inserted inside the left void at the first floor. One is a rectangular volumetric unit that stretches from the left facing surface of the void to the left external surface of the block. The other one is a curvilinear unit that does not reach the external surface of the volume.

The ground floor section consists of two interpenetrating Ls that are joined together in a way that the same curved surface defines both shapes, (TLH4 3.2, fig. 5, p. 201). These shapes are not symmetrical. Thus, there is no overall symmetry in relation to the axes of the block or to any other axis.

The first floor section consists of three rectangles, a curvilinear shape and a planar U, (TLH4 3.2, fig, 11, p. 201). The last two shapes interlock joined together by a mutual definition of surfaces. The horizontal and the vertical axes passing from the centres of these elements are not related by any symmetrical pattern to each other or to the axes of the block. The superimposition of all sections is also asymmetrical, (TLH4 3.2, fig, 29, p. 201).

Four horizontal and one vertical line are added to the grid of the first floor, (TLH4 3.3, fig. 11, p. 202). From left to right the grid bays are organised as following: B D E. From back to front the ratio is: D C D D G. There is no overall pattern of symmetry governing the relations among the geometrical bays in either of the two directions.

The superimposition of all horizontal sections results in a grid that from left to right consists of four geometrical bays arranged according to the sequence: B D F A, (TLH4 3.3, fig. 29, p. 202). From back to front six grid bays are arranged as follows: D C D D F C. Therefore, along both directions there is no overall symmetry and tripartition.

The combination of the structural grid and the ground floor grid produces sequences of grid bays that are similar to the sequences of the structural grid bays, i.e. B A A B and C C C C, (TLH4 3.4, fig. 5, p. 202). Thus, symmetry and tripartition govern this arrangement. However, the curved line is not divided at two equivalent halves by the BF axis of the block. Besides, there is no corresponding curve at the either side of the LR axis. Thus, this line breaks the symmetrical and tripartite arrangement of thegrid.

The superimposition of the structural grid and the first floor physical grid results in a grid that at length is organised as following: B D B A B, (TLH4 3.4, fig, 11, p. 202). At width the rhythm of the bays is: D D D D D F C. Thus, there is no symmetry and tripartition along both directions.

Finally, the superimposition of the structural and the physical grid of all floors creates a new grid that from left to right has the following sequence of grid bays: B D B B D B, (TLH4 3.4, fig. 29, p. 202). Thus, the consideration of the grids of the house as a whole reveals that overall symmetry and tripartition takes place with respect to the BF axis of the block and the central geometrical bay travelling along the length of the configuration. From back to front the arrangement of the grid bays is : D D D D D F A. Symmetry and tripartition are not, thus, introduced at length of the building.

At stage six the front surface of the volume is removed exposing the planar layering of the house into four horizontal slabs, (TLH4 3.1, fig. 6, p. 491). These planes are organised in pairs each of which is attached on either side of the volume. An organisation of two interlocking Us in section is revealed that are penetrated by the support elements.

The changes taking place at this stage do not alter the geometrical organisation of the house, (TLH4 3.2, p. 201, TLH4 3.3, p. 202, TLH4 3.4, p. 202). The properties remain as they are defined at the previous stages.

- **COMPARISON ACROSS STAGES**
- **Physical properties**

Subtraction at stage two destroys the physical definition of the four top vertexes, of all four horizontal edges and of a part of each vertical edge of the block, (TLH4 3.1, fig. 1, p. 491). It also destroys the physical definition of the top horizontal surface and of a part of the four vertical surfaces. Thus, at this stage the physical properties of the block are not preserved.

The addition of the roof structure aims at redefining both the initial solid and the subtracted volumetric L, (TLH4 3.1, fig. 2, p. 491). However, full physical definition of the vertexes, the edges and the surfaces of the first solid is not restored. The horizontal plane and the columns define the outline of the volume providing with both volumetric, planar and columnar readings.

At stages four and five the physical definition of the block is reduced further by the subtraction of two more volumetric elements, (TLH4 3.1, fig. 4, 5, p. 491). In this house excavation in general takes place along its length removing volumetric elements that extend from one of its sides to the other. This produces a horizontal division of the volume into four levels that is seen in its most clearest form from the left side. This division disturbs a three dimensional integration of the volume which looses, thus, its initial identity and clarity as a physical object.

Further, the excavation of the volume exposes the support elements both at the first and at the ground floor. The regular grid of the columns can be seen penetrating the volume from the ground to the top floor. The two rows of columns arranged at the extreme sides of the composition are set back from its outer surfaces. So, they do not redefine the outline of the block. Thus, although the structural frame provides with an alternative means of three dimensional integration it does not compensate the loss of physical definition produced by the sculpturing of the volume that cuts deeply into the house separating one floor level from the other by the means of intervening terraces.

The removal of the front surface at stage six, (TLH4 3.1, fig. 6, p. 491), exposes the structural frame at the front of the volume. It also exposes the planar characteristics of the slabs and of the outer walls that are joint together forming two interlocking hollow Us. The principle of interlock is introduced at this house also and is transferred to a relation between two spatial components of the interior. Besides, it characterises the relationship between the solid and the void components at the ground floor, (fig. 3.21, p. 203), as well as the relationship between the solid element at the first floor and the surrounding open space, (fig. 3.22, p. 203).

- **Geometrical properties**

At stages two, three and four the volumes in process are symmetrical as wholes along the LR axis of the block, (TLH4 3.2, TLH4 3.3, fig. 1-4, 7-10, 13-17, 19-22, 25-28, p.p. 201, 202). At stage four there is a symmetrical distribution of components along the BF axis also that operates only if all horizontal sections are superimposed, (TLH4 3.3, fig. 28, p. 202). This symmetry becomes apparent by looking at the relations among sections represented on a drawing surface. The symmetrical distribution organises elements that belong to different floor levels disturbing a three dimensional integration of these elements along a vertical axis. Thus, their relationship is never as evident as it is on a flat surface.

At the following stages the asymmetric placement of two volumetric components inside the first floor void as well as the subtraction of a volumetric L from the ground floor breaks the overall symmetry of the pattern along both axes, (TLH4 3.2 TLH4 3.3, fig. 5, 11, 29, p. 202).

Asymmetry on the level of both levels of properties is contrasted with the symmetrical arrangement of the structural grid, (TLH4 3.4, fig. 3, p. 202). If the geometrical grids of all sections are examined in relation to the structural grid then symmetry and tripartition are restored, (TLH4 3.3, fig. 26-30, p. 202). Thus, it seems that the structural grid of the house offers with a three dimensional organising device that integrates the asymmetrical organisation of the horizontal levels.

However, a differentiation is created between the properties of the superimposition of the physical grids of all sections with the structural grid and the properties of the superimposition of the physical grid of particular sections with the structural grid. Thus, the symmetrical organisation of the former along the LR axis at stages two and three, (TLH4 3.4, fig. 26, 27, p. 202) is contrasted by the symmetrical organisation of the ground the first and the second floor along both axes, (TLH4 3.4, fig. 2, 3, 8, 9, 14, 15, p. 202). Further, its symmetrical organisation along both axes at stage four, (TLH4 3.4, fig. 28, p. 202), is contrasted with the symmetrical organisation of the first and third floor along the BF axis, (TLH4 3.3, fig. 10, 22, p. 202). Finally, at the last stage symmetry along the BF axis of the 'all lines' grid is contrasted by symmetry of the third floor along the LR axis, (TLH4 3.2, fig. 24, p. 202), and symmetry of the second floor along both axes, (TLH4 3.4, fig. 18, p. 202).

The examination of the geometrical properties of this house reveals the following:

- A dissociation is created between the grid geometrical properties and the shape geometrical properties expressed by an opposition between symmetry and asymmetry. Thus, the house as a pictorial configuration of shapes looks asymmetrical. However, the examination of the grids shows that the asymmetrical organisation of the shapes generates grids that are symmetrical and tripartite with respect to an axis of the block and to a central geometrical bay running from the back to the front of the composition.

- However, a geometrical division of the block into floor levels each of which exhibits a different organising property is constructed that reinforces the physical horizontal division of the house into solid and void components. This division shows that although the different grid systems are carefully planned together and integrated around a single axis and a single geometrical bay in plan, their three dimensional integration around these principles is not possible in the external volumetric appearance of the house.

- Thus, the geometrical organisation of the house creating dissociations between the two kinds of properties and the properties of the horizontal levels demonstrates that there is not a systematic preservation and application of a simple geometrical pattern from the first to the last stages of the analysis and from the global to the local scale.

# • APPENDIX 2

## Chapter Four - PLAN ANALYSIS

### • HOUSE AT PREGASSONA-(BH2)

### • GENERAL DESCRIPTION, (illustrations 4.5-4.8, p. 227)

One enters this house through the wide openings that perforate the front and the two sides of the volume at the ground floor, (illustration 4.5, p. 227). These openings lead to a spacious portico for outdoor activities. Two vertical planes protruding into this space define the entry hall. A staircase is situated inside the vertical drum at the back of this hall. On the left and right side of the staircase two service rooms are located.

The front void penetrates deeply in the interior dividing the first floor into kitchen/study at the left and sitting area at the right sides of the plan, (illustration 4.6, p. 227). A fireplace separates the sitting area at the front from a bathroom at the back. This element falls off the ceiling to suggest a continuous space.

Ascending to the second floor the visitor reaches a landing lying in between the front void and the two terraces situated at the left and the right side of the plan, (illustration 4.7, p. 227). Two bedrooms each of which opens to a terrace are placed on either side of the front void. A third room and a bathroom flank the staircase at the back of the composition.

Light coming from the front, the sides and the top penetrates deeply into the house accentuating the sculpturing effects of the volume. It also unifies the areas of excavation into a single system that connects the various spaces together.

### • DESCRIPTION OF STAGES

As Volumetric Analysis suggested the organisation of shapes in all floors at stage one is characterised by overall symmetry on the BF axis, (TBH2 4.1, fig. 1, 4, 5, p. 255). The geometrical grids are also symmetrical and tripartite on the same axis and on the central geometrical bay running from the back to the front of the configuration, (TBH2 4.2, fig. 1, 4, 7, p. 255). Further, the organisation of the ground floor grid at width is 'just about symmetrical and tripartite, (TBH2 4.4, LR, p. 502).

At stage two both sides of the curved surface of the vertical drum are extended towards the interior in all floors, (TBH2 4.1, fig. 2, 5, 8, p. 255). A curvilinear shape is superimposed at the ground floor defined by the extensions of this surface and a glazed plane set perpendicular to them, (TBH2 4.1, fig. 2, p. 255).

Further, a volumetric L is superimposed at the back left corner of the first floor, (TBH2 4.1, fig. 5, p. 255). This element shares its outer surfaces with the surfaces of the block. A second volumetric element is superimposed at the front left corner. Its outer surfaces also coincide with the surfaces of the block as well as with the left facing surface of the void.

Two trapezoidal volumes are superimposed at the second floor on either side of the shaft, (TBH2 4.1, fig. 8, p. 255). These elements are defined by the surfaces of the block, the front void and the glazed surfaces of the terraces. Two volumetric rectangles are also superimposed on either side of the staircase. Their surfaces coincide with the surfaces of the block, the drum and the terraces.

The geometrical centre of the curvilinear shape at the ground floor lies on the BF axis, (TBH2 4.2, fig. 2, p. 255). There are no changes introduced to the arrangement of the geometrical bays at length, (TBH2 4.3, fig. 1, p. 255). Thus, symmetry and tripartition characterise the grid along this direction. The geometrical bays at width progress according to a F C H I D A pattern. This is not a symmetrical and tripartite organisation.

At the first floor the geometrical centres of the superimposed elements are not covered by any of the axes of the block, (TBH2 4.1, fig. 5, p. 255). The geometrical bays at length progress as following: E D A D E, (TBH2 4.2, fig. 5, p. 255). This is a symmetrical and tripartite pattern. The sequence of the geometrical bays at width is as following: G J C H I A D. There are no symmetrical and tripartite relations along this direction.

At the second floor the trapezoidal volumes at the front are symmetrical in terms of shape, size and position on the BF axis, (TBH2 4.2, fig. 8, p. 255). The shapes at the back left and right corners are not symmetrical in terms of size and figurative appearance. However, they are symmetrical in terms of positions they occupy on the plan. Thus, similarly to BH1 a subtle balance is created based on a contrast between symmetry in terms of one parameter and asymmetry in terms of another.

The geometrical bays progress at length as following : E D A D I K, (TBH2 4.2, fig. 8, p. 255). The Symmetry Grid index index is 0.88, (TBH2 4.4, p. 502). Thus, the organisation of the grid bays at length is 'just about' symmetrical and tripartite. The grid bays at width progress according to a A J I D H I F sequence. There is no symmetry and tripartition characterising the organisation of the grid bays in this direction.

Two out of five lines, (2/5), defining the elements of the interior at the ground floor coincide with the elements of the exterior, (I/O Line index: 0.20, TBH2 4.5, p. 502). At the first floor ten out of the twelve lines, (10/12), defining the superimposed elements coincide with lines defining the elements of the external articulation, (I/O Line index: 0.83). At the second floor twelve out of seventeen lines, (12/17), of the superimposed shapes coincide with lines of the elements of the external articulation, (I/O Line index: 0.70).

At stage three two volumetric rectangles are superimposed at the left and right side of the drum at the ground floor, (TBH2 4.1, fig. 3, p. 255). A thick partition is added at the right side of the first floor plan, (TBH2 4.1, fig. 6, p. 255). A volumetric rectangle is also superimposed at the back right corner sharing its outer surfaces with the surfaces of the block and the drum. The second floor plan remains as defined at stage two, (TBH2 4.1, fig. 8, 9, p. 255).

At the ground floor the superimposed rectangles are symmetrical with respect to the BF axis, (TBH2 4.1, fig. 3, p. 255). The lines defining these shapes coincide with the lines defining the elements of the external organisation, (TBH2 4.2, fig. 3, p. 255). Thus, there are no changes to the geometrical grid at length. Therefore, symmetry and tripartition characterise the grid along this direction. At width the arrangement of the grid bays is based on the following sequence: A D C H I D A. This is not a symmetrical and tripartite pattern.

The geometrical centres of the new elements at the first floor are not covered by any of the axes of the block, (TBH2 4.1, fig. 6, p. 255). The geometrical grid progresses at length as following: E D A D A I D, (TBH2 4.2, fig. 6, p. 255). This not a symmetrical and tripartite pattern. The Symmetry Grid index is : 0.81, (TBH2 4.4, p. 502). Thus, the organisation of the grid bays is 'just about' symmetrical and tripartite. At width the sequence of the grid bays is as following: C J J C H I A D. There is no symmetry and tripartition along this direction.

There are no changes occurring at the second floor plan. Thus, the shape and the grid organisation remain as described at stage two, (TBH2 4.2, fig. 8, 9, p. 255).

Five out of eleven lines defining the elements of the interior at the ground floor, (5/11), coincide with the lines defining the elements of the exterior, (I/O Line index: 0.45), (TBH2 4.5, p. 502). At the first floor this ratio is eleven to fifteen, (11/15, I/O Line index: 0.73).

- **COMPARISON ACROSS STAGES**

- **Physical properties**

At stage one the four corners of the block are defined by opaque surfaces in all floor levels, (TBH2 4.1, fig. 1, 4, 7, p. 255). At the ground floor regardless of the large openings that perforate the volume, the broken surfaces of the block are implicitly present, (TBH2 4.1, fig. 1, p. 255). Thus, at this level the block retains its physical presence as a geometrical shape.

At the first floor the corners of the block are defined by opaque surface, whereas the corners of the void are defined by both opaque and transparent ones, (TBH2 4.1, fig. 5, p. 255). These corners define also the volumetric U. Thus, a distinction of material defining the corners of these elements articulates a distinction between the block and the smaller components.

Besides, as opposed to the block all corners of which provide volumetric readings, the corners of the void and the U provide planar readings. The planar decomposition of the latter breaks their volumetric clarity strengthening the identity of the initial solid. Besides, this decomposition occurs at the points of intersection of their surfaces with the outer surfaces of the volume. This allows these surfaces to extend towards the completion of the block. Thus, the initial solid is physically present registering as a clearly recognisable element.

The symmetrical distribution of the opaque and glazed surfaces with respect to the BF and the LR axes of the block reinforces the co-ordinating role of these axes. The intensification of the geometrical properties of the block results in a further intensification of its physical presence[19].

Thus, the explicit/implicit physical definition and the distribution of material along the surfaces of a shape are not the only factors that determine its unity. The geometrical properties of contours can also specify the ways an arrangement is perceived as a whole. In this case the uniform physical definition of the corners of the block by identical physical elements and the geometrical co-ordination of these elements by the overall symmetries of the plan make it register as a complete and identifiable physical element.

At the second floor the two back corners of the void are defined by opaque and transparent surfaces. Besides, two of the corners of the volumetric U[20] facing the side voids and two of its corners facing the front void are defined by opaque surfaces, (TBH2 4.1, fig. 7, p. 255). The rest of its corners are defined either by glazed or by both opaque and glazed surfaces. Thus, a distinction of material articulates a distinction between the block and the rest of the elements.

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19 Analysis examines the physical and the geometrical properties across stages separately from each other. However, it looks also at the ways the two kinds of properties interact in structuring intelligibility of a volume. Thus, although the geometrical properties are examined at the following section, an account of the ways they hold the surfaces of a volume together is given at this section. The aim is to explain how the geometrical properties affect its definition as a physical concept.

20 The largest volume at the second floor resulted from the subtraction of two volumetric components from the sides of a volumetric U. Although this volume is not a clear volumetric U analysis uses this term for economy of expression.

Besides, as opposed to the block that is composed of volumetric components, the void is decomposed into planar components. The volumetric U is also decomposed into volumetric and planar elements. Thus, the block reads as volumetric element of a uniform contour. On the other hand, the void and the volumetric U lack uniformity providing both volumetric and planar readings.

However, the corners of the U facing the terraces and the corners facing the front void provide volumetric readings that interrupt the implicit extension of the outer surfaces towards the completion of the block. Thus, simultaneous readings of the U, of L shaped surfaces and the block are constructed that challenge the predominance of the latter.

Nevertheless, in the absence of a prevailing shape, the geometrical co-ordination of the surfaces on the BF and LR axes and the physical uniformity of the corners of the block establish its priority over the rest of the components.

At stage two the extension of the curvilinear surface at the ground floor interrupts the implicit continuity of the back surface of the block[21], (TBH2 4.1, fig. 2, p. 255). However, the line completing its contour is inferred continuing behind the curvilinear rectangle. Thus, the block retains its recognisability as a physical element.

At the first and second floor the simultaneous definition of the superimposed elements and the block by the outer surfaces creates simultaneous readings of the large and the small scale components, (TBH2 4.1, fig. 5, 8, p. 255). In BH1 a distinction between opaque and transparent surfaces establishes the priority of the block over the rest of the elements. However, unlike BH1 the large and the small scale shapes are defined by both opaque and glazed surfaces.

Nevertheless, the four corners of the block are physically defined by opaque surfaces. On the other hand, certain corners of the superimposed shapes lack full physical definition, while others are defined either by both opaque and glazed surfaces, or by glazed surfaces only. Thus, whereas the block retains its volumetric coherence as a physical entity, the elements of the interior are decomposed into volumetric and planar components.

At the first floor the planar decomposition of the superimposed shapes occurs at the points of intersection of their surfaces with the outer surfaces of the volume, (TBH2 4.1, fig. 5, p. 255). This allows the latter to continue towards the completion of the largest volumetric rectangle.

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21 R. Arnheim suggests that in two overlapping shapes the unit the contour of which is interrupted takes the back position. R. Arnheim, 'Art and Visual Perception, A Psychology of the Creative Eye', The new Version, University of California Press, Berkeley Loss Angeles, California, London, p. 249.

On the contrary, at the second floor a volumetric definition of certain corners of the superimposed elements occurs at the points of intersection of their defining lines with the outer surfaces, (TBH2 4.1, fig. 8, p. 255). This interrupts the implicit extension of the latter towards the completion of the block. However, the volumetric definition of the corners of the block as opposed to the absence of a consistent pattern of definition of the corners of the superimposed shapes enables its readings to prevail.

Besides, the symmetrical co-ordination of the opaque and the transparent surfaces with respect to the BF and the LR axes in both floors reinforces the geometrical properties of the initial solid. An increase in the strength of these axes increases the strength of its physical presence.

Similarly to stage two at stage three the superimposed elements at the ground and the first floor share their defining surfaces with the surfaces of the block, (TBH2 4.1, fig. 3, 6, p. 255). At the first floor the simultaneous readings of the elements of the internal and the external articulation are resolved by the decomposition of the former into volumetric and planar components, (TBH2 4.1, fig. 6, p. 255). Planar decomposition occurs at the point of intersection between the surface of the superimposed shape and the outer surfaces of the block. Thus, the latter continue uninterrupted towards the completion of the initial volume.

At the ground floor a volumetric definition of the corners of the superimposed elements occurs at the points of intersection between their defining surfaces and the outer surfaces of the volume, (TBH2 4.1, fig. 3, p. 255). This interrupts the implicit extensions of the latter to complete the block. However, the absence of uniform physical definition of the corners of these shapes analyses their volume into two U surfaces. Thus, these rectangles lacking volumetric coherence allow the reading of the block to prevail.

To summarise, from stage one to stage three a gradual superimposition of elements increases the number of shape readings provided by the physical elements of the external articulation. However, the distribution of material along the periphery of these elements preserves the hierarchical distinction amongst the initial solid and the rest of the components. This is achieved by a sharp contrast based on the volumetric clarity of the block and the planar decomposition of the rest of the shapes.

- **Geometrical properties.**

The shape properties of the ground floor are governed by overall symmetry on the BF axis throughout the stages, (TBH2 4.1, fig. 1-3, p. 255). At the first floor the organisation of the shapes moves from overall symmetry at stage one to asymmetry at stages two and three, (TBH2 4.1, fig. 4, 5, p. 255). At the second floor the overall symmetry characterising the shape organisation at stage one is transformed to 'just about' symmetry at stages two and three, (TBH2 4.1, fig. 7, 8, p. 255, TBH2 4.3, p. 502).

Besides, a division between the front and the back of this plan is constructed at the second floor based on the symmetrical arrangement of shapes at the front of the plan and an asymmetrical one at the back of it.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 1 |
| 1ST | 1 | 0.66 | 0.50 |
| 2ND | 1 | 0.88 | 0.88 |

**Table BH2 4.3** - SYMMETRYSHAPE INDEX, (BF) - No of shapes sym on the BF axis/Total no of shapes

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 1 |
| 1ST | 1 | 1 | 0.81 |
| 2ND | 1 | 0.91 | 0.91 |

**Table BH2 4.4** - SYMMETRY GRID INDEX, (BF) - No of geom lines sym on the BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.80 | 0.62 | 0.55 |
| 1ST | 0.50 | 0.45 | 0.41 |
| 2ND | 0.50 | 0.38 | 0.38 |

**Table BH2 4.4, LR** - SYMMETRY GRID INDEX, (LR) - No of geom lines sym on LR axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.20 | 0.45 |
| 1ST | | 0.83 | 0.73 |
| 2ND | | 0.70 | 0.70 |

**Table BH2 4.5** - INSIDE/OUTSIDE LINE INDEX - No of geom lines of the internal and external elements/Total no of lines

However, a balanced asymmetry created at the back of the plan reinforces the co-ordinating role of the BF axis.

Thus, whereas at the ground floor the shape organisation of the interior coincides with that of the exterior, at the second floor becomes a close approximation of the latter. Finally, at the first floor the properties of the internal articulation do not preserve the symmetrical organisation characterising the external one. However, as analysis suggested the geometrical co-ordination of the glazed and opaque surfaces of the block intensifies the BF axis.

The geometrical grid of the ground floor remains symmetrical and tripartite throughout the stages, (TBH2 4.2, fig. 1, 2, 3, p. 255, TBH2 4.4). At the first floor it changes from overall symmetry and tripartition on the BF axis at stages one and two to 'just about' symmetry and tripartition at stage three, (TBH2 4.2, p. 255, fig. 4, 5, 6, TBH2 4.4). At the second floor the geometrical grid is transformed from a symmetrical and tripartite grid at stage one to a 'just about' symmetrical and tripartite grid at stage two, (TBH2 4.2, fig. 7, 8, 9, p. 255, TBH2 4.4).

Thus, the properties of the exterior at the ground floor coincide with those of the interior. At the first and the second floor the former become close approximations of the latter. The Symmetry Grid index of the first and second floors shows that the grid of the second floor is governed by symmetry to a greater extent than the grid of the first floor, (0.91 as opposed to 0.81), (TBH2 4.4). Thus, at the second floor the association between the properties of the internal and the external articulation becomes stronger than at the first floor.

At width the grid organisation of all floors is not characterised by overall symmetry or 'just about' symmetry in any stage[22], (TBH2 4.3, fig. 1-9, TBH2 4.4). Volumetric Analysis suggested that the BF axis is stronger than the LR axis organising each individual level as well as the volume as a whole. This analysis shows that this distinction is accentuated further by the internal organisation.

The I/O ILne index at the ground floor increases from 0.20 at stage two to 0.45 at stage three. At the first floor it drops from 0.83 to 0.73. Finally, at the second floor it is 0.70, (TBH2 4.5). The high values of this index at the first and second floor indicate that it is not only the grid properties of the interior and those of the exterior that coincide but also the grid elements of the former and the grid elements of the latter.

Thus, rules are applied from outside-in ensuring that the geometrical properties of the external articulation determine the geometrical properties of the internal articulation. They also ensure that the

22 It is only the ground floor grid at stage one that is characterised by 'just about' symmetry and tripartition, (TBH2 4.4, fig. 1).

new surfaces are aligned with the existing ones. Few lines are introduced to the grids during the transformation process of the interior keeping the grid configuration as simple as possible and as close to the grids of the previous stages as possible.

Looking at the relationship between the shape and the grid organisation it turns out that at the ground and second floor a coincidence is constructed between the two levels of properties, (TBH2 4.3, TBH2 4.4, p. 502). This is based on the symmetrical or 'just about' symmetrical organisation of both. At the first floor a dissociation is constructed between the two levels of properties.

To summarise, at the ground and second floors the shape and grid properties of the interior become close approximations of the overall symmetrical and tripartite structure of the external articulation. At the first floor it is only the grid organisation that does so. In this floor the obvious symmetries of the physical components are substituted with subtler symmetries of their organising geometrical lines. The systematic strengthening of the properties of the exterior shows a systematic tendency to preserve and strengthen the properties of the initial solid.

# HOUSE AT MASSAGNO-(BH3)

## GENERAL DESCRIPTION, (illustrations 4.9-4.12, p. 228)

Access to this house is through a portico that extends parallel to the front facade, (illustration, 4.11a, p. 228). One enters through the vertical shaft that penetrates throughout the building. An entry hall is placed along the lateral axis. This hall opens to four service spaces occupying the corners of the layout. On the axis of entry the staircase is placed defined by the cylindrical surface of the vertical drum.

The staircase and the shaft divide the first floor into kitchen-dining at the left and sitting areas at the right side of the plan, (illustration, 4.11b, p. 228). These areas open to a terrace that stretches from the centre to the left side of the composition. There are no clear separations between the spaces allowing views to reach the extreme sides of the volume along both directions. Thus, a spatial continuity between the spaces of the interior as well as between the interior and the exterior is created, (illustration 4.10-4.12, p. 228). This continuity is asserted by the uninterrupted extension of the vertical and the horizontal surfaces over the entire area of the plan.

At the second floor two bedrooms are located at the left side of the shaft and the outside space, (illustration 4.11c, p. 228). A bedroom is also located at the right side of these spaces that is vertically connected with the sitting area below through a void. The left to right distinction is also expressed by two bathrooms each of which is situated on either side of the staircase at the back of the composition.

Long views that reach the outer boundaries of the volume are constructed through the glazed surfaces of the void connecting the bedrooms, (illustration 4.12, p. 228). Thus, a spatial continuity is created between the interior and the exterior at this floor also. This continuity is asserted by the uninterrupted extension of the horizontal and vertical surfaces throughout the plan.

## • DESCRIPTION OF STAGES

At stage one there is 'just about' symmetry organising all floors, (TBH3 4.1, fig. 1, 4, 7, p. 256, TBH3 4.3, p. 509). The arrangement of the grid bays at length at the ground floor is according to the sequence: F G B A B H I. The Symmetry Grid index is: 0.77, (TBH3 4.1, fig. 1, p. 256, TBH3 4.4, p. 509). This is a 'just about' symmetrical and tripartite pattern. At the first and second floor the grid bays progress as following: D E B A B E D. Although this organisation looks symmetrical and tripartite there is an oblique line in both floors that breaks the overall pattern of symmetry. The Symmetry Grid index is: 0.90 and 0.91 respectively, (TBH3 4.4, p. 509). Therefore, there is 'just about' symmetry and tripartition.

At width the bays of the ground floor progress as following: D A G H. At the first and second floor they progress according to the rhythm: D A D. According to the Symmetry Grid index the organisation of all grids is asymmetrical on the LR axis[23].

At stage two the cylindrical surface of the drum is extended towards the interior in all floors, (TBH3 4.1, fig. 2, 5, 8, p. 256). A volumetric L is superimposed on either side of the shaft at the ground floor plan, (TBH3 4.1, fig. 2, p. 256). The outer surfaces of these shapes are defined by the surfaces of the block, the shaft and the outside space. At the first floor a rectangle is superimposed on either side of the drum at the back of the composition, (TBH3 4.1, fig. 5, p. 256). The back surfaces of these elements coincide with the back surface of the block. At the second floor a thick partition is added as a free standing element at the left side of the plan, (TBH3 4.1, fig. 8, p. 256). Besides, a spatial L, one side of which is oblique, is superimposed on the other side. The outer surfaces of this element coincide with the surfaces of the block, the shaft and the outside space.

The superimposed shapes at the ground floor are not symmetrical to each other with respect to any of the axes of the block, (TBH3 4.1, fig. 2, p. 256). There is no symmetry or 'just about' symmetry organising the shape properties in this floor, (Symmetry Shape index: 0.50, (TBH3 4.3, p. 509). Nevertheless, these shapes are symmetrical on the BF axis in terms of positions they occupy on the plan. Thus, there is a contrast between asymmetry in terms of their figurative appearance and symmetry in terms of their position.

The geometrical grid consists of eight geometrical bays at length that progress as following: F B B B A B B G I, (TBH3 4.2, fig. 2, p. 256). The Symmetry Grid index is 0.81, (TBH3 4.4, p. 509). Thus, the organisation of the grid bays is 'just about' symmetrical and tripartite. At width there are four geometrical bays that proceed as follows: D A G H. There is no symmetry and tripartition along this direction.

There is no shape symmetry characterising the organisation of the first floor, (TBH3 4.1, fig. 5, p. 256, TBH3 4.3, p. 509). The two superimposed rectangles are not symmetrical to each other with respect to the BF axis. However, they have approximately the same size and proportions. Further, the distance of their geometrical centres from the BF axis is almost but not exactly the same. Thus, a balanced asymmetry characterises the organisation of these shapes based on asymmetrical appearance and 'just about' symmetrical positions with respect to the BF axis.

The geometrical grid consists of ten geometrical bays at length that are arranged according to a E B H B B A B H G G H rhythm, (TBH3 4.1, fig. 5, p. 256). There is no symmetry or tripartition governing this

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23 Similalry to the organisation of the first and second floor at length, the overall symmetrical pattern of the geometrical bays at width in these floors expressed through the D A D sequence is broken by the oblique lines.

arrangement. At width the grid bays progress as following: G H A D. There are no symmetrical and tripartite relations along this direction either.

At the second floor the superimposed L and the free standing element have no equivalent elements at the other side of the BF axis, (TBH3 4.1, fig. 8, p. 256). Similalry to the floors below, there is no shape symmetry characterising this plan, (TBH3 4.3, p. 509). The sequence of the geometrical bays from left to right is as following: K A A J B A B H B D, (TBH3 4.2, fig. 8, p. 489). From back to front the arrangement of the grid bays is according to a D B H D sequence. There is no symmetry or tripartition characterising the organisation of this grid along both directions.

Fourteen out of fifteen, (14/15), of the defining lines of the shapes of the interior at the ground floor coincide with the defining lines of the external articulation, (I/O Line index: 0.93), (TBH3 4.5, p. 509). At the first floor six out of eleven lines, (6/11), that define the volumetric rectangles coincide with the lines of the external articulation, (I/O Line index: 0.54). Finally, at the third floor twelve out of sixteen lines, (12/16), defining the elements of the internal articulation coincide with the lines defining the elements of the external articulation, (I/O Line index: 0.75).

At stage three a volumetric L is superimposed at the back left corner of the ground floor, (TBH3 4.1, fig. 3, p. 256). A spatial rectangle is also superimposed at the back right corner of this plan. The back and side surfaces of these elements coincide with the surfaces of the block. Further, a spatial rectangle is superimposed at the front left corner of the plan. Two of the surfaces of this shape coincide with the surfaces of the block. The first floor remains as defined at the previous stage, (TBH3 4.1, fig. 5, p. 256). At the second floor a volumetric rectangle is superimposed on each of the back right and left side of the plan, (TBH3 4.1, fig. 9, p. 256). The back surface of these elements coincides with the back surface of the block.

There is no shape symmetry governing the organisation of any floor, (TBH3 4.3, p. 509). However, similarly to stage one the asymmetrical figurative appearance of the elements superimposed at the back of the ground floor is contrasted with their symmetrical positions on the plan, (TBH3 4.1, fig. 3, p. 256).

The geometrical grid progresses at length according to a sequence: A A B B B B A B B G I, (TBH3 4.2, fig. 3, p. 256). The Symmetry Grid index is 0.69, (TBH3 4.4, p. 509). Thus, the organisation of the grid bays approximates 'just about' symmetry and tripartition. The arrangement of the grid bays at width is based on a H G A J B H sequence. The Symmetry Grid index is 0.75, (TBH3 4.4, LR, p. 509). Thus, this is a 'just about' symmetrical and tripartite organisation.

At the second floor the geometrical grid at length is organised according to a K B K K B J B A B H B D G sequence, (TBH3 4.2, fig. 9, p. 256). At width the geometrical bays are arranged as following: G H B H D. There are no symmetrical and tripartite relations along both directions.

Fifteen out of twenty, (15/20), lines defining the elements of the interior at the ground floor coincide with the lines defining the elements of the exterior, (I/O Line index: 0.75), (TBH3 4.5, p. 509). At the second floor fourteen out of twenty one, (14/21), lines defining the elements of the interior coincide with the lines of the external articulation, (I/O Line index: 0.66).

- **COMPARISON ACROSS STAGES**

- **Physical properties**

At stage one the surfaces and the corners of the block are defined by opaque material, whereas those of the void and the shaft are defined by both opaque and transparent material, (TBH3 4.1, fig. 1, 4, 7, p. 256). Thus, a distinction between opaque and glazed surfaces distinguishes between the block, the shaft and the void in all plans.

Besides, whereas the corners of the block are defined by opaque surfaces, the corners of the shaft and the void are defined by both opaque and transparent ones. Thus, the elements of the former group themselves to define a volumetric shape, whereas the elements of the latter decompose themselves to define planar components. Therefore, the block retains its physical coherence as a single volume as well as its hierarchical differentiation from the rest of the elements[24].

At stage two the extended surfaces of the drum interrupt the implicit continuity of the back surface of the block in all floors, (TBH3 4.1, fig. 2, 5, 8, p. 256). However, this surface is inferred travelling 'behind' the drum. Thus, the recognisability of the block is retained.

At the ground and second floor the simultaneous definition of the superimposed shapes, the block, the shaft and the void by the same surfaces creates simultaneous readings of these elements, (TBH3 4.1, fig. 2, 8, p. 256). However, a difference in the material defining these elements creates hierarchical distinctions among them. Thus, the sides and the three corners of the block are defined by opaque surfaces only. On the other hand, three sides of the superimposed Ls are defined by glazed surfaces, while three of their corners are defined by both opaque and glazed surfaces. Finally, the fourth corner lacks complete physical definition[25].

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24 Although one of the corners of the block lacks full physical definition, an implicit physical definition of this corner and the physical continuity of the rest of the physical elements defining its contour restore its physical identity.

25 This is because entry to these spaces is placed at this position.

Thus, whereas the block is characterised by a uniform contour, the rest of the elements lack physical uniformity. Besides, whereas the block reads as a spatial volumetric rectangle, the rest of the elements provide with both volumetric and planar readings.

The volumetric decomposition of the superimposed elements occurs at the point of intersection of their surfaces with the surfaces of the block. This allows the outer surfaces of the latter to continue towards the completion of the largest volume. Thus, the physical identity of the largest rectangle prevails over the rest of the components.

At the first floor the block shares only one surface with each of the superimposed rectangles and none of its corners, (TBH3 4.1, fig. 5, p. 256). This coupled with differences in terms of thickness of the walls defining the block and the spatial rectangles results in a predominance of the former over the latter. The physical identity of the block as a coherent spatial volume is thus, preserved.

At stage three the L superimposed at the back left corner, and the rectangles superimposed at the back right and the front left corner of the ground floor share two of their defining surfaces with the surfaces of the block, (TBH2 4.1, fig. 3, p. 256). Similarly to stage two differences in material defining the block and these elements contributes to the predominance of the block over these elements. There are no changes introduced to the first floor plan at this stage.

At the second floor the two rectangles superimposed at the back of the plan share only one surface with the block, (TBH2 4.1, fig. 9, p. 256). In this way, the physical coherence of the latter is not affected.

Thus, in every stage the majority of the defining surfaces of the new elements coincide with the surfaces of the elements of the volumetric articulation. However, regardless of the increased complexity in the number of relations that these surfaces enter, differences in boundary material amongst the superimposed shapes, the block, the shaft and the drum retain the physical coherence of the elements of the large scale. This physical coherence appears stronger in the first floor where the number, the size and the position of the superimposed elements are such as to preserve the physical identity of the block.

- **Geometrical properties.**

At stage one there is 'just about' shape symmetry governing the relations among the block, the shaft and the curvilinear element at the back of the volume. Analysis of the following stages showed that the disposition of the superimposed and the added shapes is not governed by symmetry with respect to any of the axes of the block, (TBH3 4.1, fig. 1-9, p. 256). Thus, the shape properties of the interior do not reinforce the 'just about' symmetry of the external articulation.

However, a subtle balance is created based on a contrast between asymmetrical relations among these elements in terms of one shape parameter and symmetrical relations in terms of another parameter. This

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.75 | 0.50 | 0.30 |
| 1ST | 0.75 | 0.50 | 0.50 |
| 2ND | 0.80 | 0.57 | 0.40 |

**Table BH3 4.3** - SYMMETRY SHAPE INDEX, (BF) - No of shapes sym on BF axis/Total no of shapes

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.77 | 0.81 | 0.69 |
| 1ST | 0.90 | 0.35 | 0.35 |
| 2ND | 0.91 | 0.60 | 0.50 |

**Table BH3 4.4** - SYMMETRY GRID INDEX, (BF) - No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.66 | 0.66 | 0.75 |
| 1ST | 0.66 | 0.57 | 0.57 |
| 2ND | 0.50 | 0.66 | 0.60 |

**Table BH3 4.4, LR** - SYMMETRY GRID INDEX, (LR) - No of geom lines sym on LR axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.93 | 0.75 |
| 1ST | | 0.54 | 0.54 |
| 2ND | | 0.75 | 0.66 |

**Table BH4 4.5** - INSIDE/OUTSIDE LINE INDEX - No of geom lines of the internal and external elements/Total no of lines

close approximation reinforces the local pattern of symmetry governing the elements of the external articulation.

The grid properties of the ground floor remain 'just about' symmetrical and tripartite throughout the stages with respect to the BF axis, (TBH3 4.2, fig. 1-3, p. 256, TBH3 4.4). At the rest of the floors the 'just about' symmetrical and tripartite grid at stage one is transformed to an asymmetrical grid in both directions, (TBH3 4.2, fig. 4-9, p. 256, TBH3 4.4, BF, TBH3 4.4, LR).

Thus, the 'just about' symmetrical and tripartite grid of the external organisation does not coincide with the asymmetrical and non tripartite grid of the internal organisation apart from the ground floor. However, the symmetrical and tripartite structuring of the central geometrical bay from back to front and the ones arranged on its sides is retained in all floors throughout the stages. Thus, although the 'just about' symmetries of the first stage are not preserved local symmetries existing at this stage are retained.

The embedment of symmetries within an overall asymmetrical organisation functions similarly to the balanced asymmetries of the shape organisation. Thus, they result in an intensification of the BF axis through a provision of its formal opposite.

Looking at the relationship between the shape and the grid properties it turns out that the only association created between these properties refers to the asymmetrical development of both along the analytic stages.

The I/O Line index at the ground floor moves from 0.93 at stage two to 0.75 at stage three, (TBH3 4.5). At the first floor this index is 0.54. Finally, at the third floor it moves from 0.75 to 0.66. Thus, it turns out that although there is no embedment of the rules of the interior organisation to those of the external organisation, there are restrictions dictating the positioning of the lines that define the elements of the interior. According to these restrictions the newly introduced lines coincide with the existing lines of the volumetric articulation.

The first floor has the lowest I/O Line index value, (0.54). This indicates that there are no global rules affecting the positioning of the grid lines of the interior. However, the internal articulation in this floor is mainly a matter of the external ordering, i. e. the grid lines of the exterior define also the interior. This is because the superimposed elements occupy a small area of the plan allowing the elements of the volumetric articulation to shape also the interior. In this respect, internal and external ordering are achieved by the same manoeuvre. Thus, the interior is subordinated to the exterior at this floor also.

To summarise, there is no consistent pattern of coincidence between the properties of the interior in process and the properties of the first stage. Thus, there is no emphasis on an association between the properties of the exterior and those of the interior. However, an embedment of the rules governing the internal articulation to the rules governing the external one is constructed through the subtle asymmetries characterising the disposition of the shapes and the grid lines. Besides, grid lines are subjected into restrictions of alignment arising from the rules of the volumetric articulation.

- **HOUSE AT STABBIO - (BH4)**

- **GENERAL DESCRIPTION, (illustrations 4.13-4.16, p. 229)**

A pair of openings that are symmetrical on the BF axis are situated at the front and the back of the house giving access to the ground floor, (illustration 4.15a, p. 229). An entry hall is placed on the dominant axis dividing the plan into two portico areas. The portico area at the left side of the plan is occupied by two service rooms. The direction of entry is along the perpendicular axis marked by the two door entrances on either side of the entry hall, (illustration 4.13, p. 229). At the end of the north - south axis the staircase is found leading to the floors above.

Reaching the first floor landing the visitor is offered views to the outside through a large opening at the front of the house, (illustration 4.14, p. 229). An opening at the ceiling creates a vertical connection between this level and the level above. A cylindrical column is located on either edge of this opening extending to the top of the house. Light coming from the front and the skylight accentuates further this vertical condition.

The opening at the ceiling creates an implicit division of the plan into dining and sitting areas. The staircase acts also as a programmatic device splitting the back of the composition into a kitchen and a guest room. The former opens to the dining whereas the latter is separated from the sitting by a fireplace.

At the second floor the opening and the staircase divide the plan into two compartments, (illustration 4.15c, p. 229). The one at the left accommodates two bedrooms separated by a bathroom. The one at the right houses a bedroom at the front and a bathroom at the back of the composition, (illustration 4.16, p. 229). Unlike the spatial continuity occurring at the first floor, a division of space into separate rooms characterises this level.

The lack of dividing walls at the first floor and the vertical link between the floors construct long views that reach the outer surfaces of the house along the horizontal and vertical direction. These views suggest that the interior is also treated as a single volume. The vertical links occur at the strategic location of the BF axis to underline a unification of the internal void, the external void, the skylight and the stair drum into a single structure.

- **DESCRIPTION OF STAGES.**

Volumetric analysis suggested that all floor plans seen as arrangements of both shapes and grid lines are symmetrical as wholes on the BF axis and tripartite on the central geometrical bay running from back to front[26], (TBH4 4.1, fig. 1, 4, 7, p. 257). The arrangement of the grid bays at length at the ground floor is based on the E B B A B B E sequence, (TBH4 4.2, fig. 1, p. 257). At the first floor the grid bays progress according to the following rhythm: E F F B A B F F E, (TBH4 4.2, fig. 1, 4, 7, p. 257). Finally, at the second floor the sequence of the grid bays is as following: I H B A B C, (TBH4 4.2, fig. 1, 4, 7, p. 257).

At stage two the semicylindrical surface of the drum is extended towards the interior in all floor plans, (TBH4 4.1, fig. 2, 3, 8, p. 257). At the ground floor the surfaces of the curvilinear volume at the front of the plan are also extended towards the interior. A volumetric component is superimposed on this plan defined by the extended surfaces of the drum, the extended surfaces of the curvilinear volume and two oblique surfaces, (TBH4 4.1, fig. 2, p. 257).

There are no changes introduced at the first floor plan apart from the extension of the surfaces of the drum, (TBH4 4.1, fig. 5, p. 257). At the second floor the surfaces of the front void are extended towards the interior, (TBH4 4.1, fig. 8, p. 257). An opening is defined on the floor establishing a vertical connection with the floor below[27]. Three volumetric elements are also superimposed at the left side of the plan the outer surfaces of which coincide with the outer surfaces of the cylinder.

The geometrical centre of the superimposed component at the ground floor is situated on the BF axis, (TBH4 4.1, fig. 2, p. 257). Thus, there is overall symmetry governing the shape organisation of this floor. The sequences of the grid bays at length and width are similar to the sequences of the previous stage, (TBH4 4.2, fig. 1, 2, p. 257). In this respect symmetry and tripartition characterise the grid from left to right. At width the geometrical grid is and 'just about' symmetrical and tripartite, (Symmetry Shape index: 0.83, TBH4 4.3, LR, p. 515).

At the first floor the extended surfaces of the drum are symmetrically extended into the interior[28], (TBH4 4.1, fig. 5, p. 257). There is overall symmetry characterising the organisation of shapes. The sequence of the geometrical bays along both directions remains as it is defined at stage one, (TBH4 4.2, fig. 4, 5, p.

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26 The only exception is the second floor which is characterised by 'just about' shape and grid symmetry on the BF axis, Symmetry Shape index: 0.71, Symmetry Grid index: 0.85, (TBH4 4.3, TBH4 4.4, p. 515).

27 Perforation occurs at the extensions of the lines that constitute the front void.

28 The extended surfaces of the drum do not define a closed geometrical shape. However, analysis treats the extended surfaces as linear elements that are subjected to the overall shape symmetry of the plan.

257). Thus, symmetry and tripartition characterise the grid from left to right. There is no symmetry or tripartition governing the articulation of the grid from back to front.

At the second floor the geometrical centre of the floor opening lies on the BF axis, (TBH4 4.1, fig. 8, p. 257). The extended surfaces of the drum are also symmetrical to each other with respect to this axis. The superimposed shapes at the left have no equivalent shapes at the right side of the plan. Nevertheless, there is 'just about' symmetry organising the distribution of shapes, (Symmetry Shape index: 0.72, TBH4 4.3, p. 515).

The geometrical centre of the superimposed element situated in between the two superimposed shapes at the left side of the plan lies on the LR axis. The other two shapes are 'just about' but not exactly symmetrical on this axis. This is because the top part of the shape at the back is different from the bottom part of the equivalent shape at the front of the composition. Thus, local symmetries characterise the organisation of the shapes at width.

The geometrical grid consists of seven geometrical bays at length that progress according to the following sequence: I D L B A B C, (TBH4 4.2, fig. 8, p. 257). The symmetry Grid index is: 0.75. This is a 'just about' symmetrical and tripartite pattern. The sequence of the grid bays at width remains as defined at stage one, (TBH4 4.1, fig. 1, 8, p. 257). Thus, there is no symmetry or tripartition governing the organisation of the grid bays in this direction.

At the ground floor every line generated by the extensions of the surfaces of the superimposed element coincides with a line generated by the elements of the external articulation, (8/8, I/O Line index: 1), (TBH4 4.5, p. 515). At the first floor the extended surfaces of the drum are the only surfaces of the interior. These surfaces coincide with the semi - cylindrical surface of the drum. Thus, the I/O Line index for this floor is also 1. Finally, at the second floor ten out of twelve, 10/12, lines defining the elements of the interior coincide with lines generated by the elements of the exterior, (I/O Line index: 0.83).

At stage three two curvilinear components are superimposed at the left side of the ground floor, (TBH4 4.1, fig. 3, p. 257). Two curvilinear shapes are also superimposed at the front side of this plan. At the first floor an L shaped partition and a rectangular partition are added to the left and the right side of the staircase respectively, (TBH4 4.1, fig. 6, p. 257). At the second floor a partition is attached at the right surface of the staircase, (TBH4 4.1, fig. 9, p. 257). A second partition is added at the right side of the plan screening the bedroom from the central area of the plan.

The geometrical centres of the curvilinear shapes superimposed at the front of the ground floor are symmetrical with respect to the LR axis, (TBH4 4.1, fig. 3, p. 257). Besides, there are no shapes at the right side of the BF axis that are equivalent to the superimposed shapes at the left side of the plan. Thus, there is no overall symmetry governing the distribution of shapes on the BF axis.

The geometrical bays progress at length according to the sequence: E B B F B B B E, (TBH4 4.2, fig. 3, p. 257). This is not a symmetrical and tripartite organisation. However, the Symmetry Grid index is 0.90. Thus, the geometrical grid is 'just about' symmetrical and tripartite. The Symmetry Grid index at width is : 0.88, (TBH4 4.4, LR, p. 515). This is a tripartite and 'just about' symmetrical organisation.

At the first floor the rectangular and the L shaped partition are not symmetrical to each other with respect to the BF axis, (TBH4 4.1, fig. 6, p. 257). Thus these two shapes contradict the overall pattern of symmetry characterising the rest of the elements. However, the strong symmetry characterising the cylinder, the drum and its extended surfaces, as well as the curvilinear terrace at the front of the volume becomes dominant subordinating the deviations from symmetry created by the elements of the small scale. The Symmetry Shape index is 0.77, (TBH4 4.3, p. 515). Thus, the organisation of the shapes is 'just about' symmetrical.

The arrangement of the grid bays at length is as follows: E F F I L A B F F E, (TBH4 4.2, fig. 6, p. 257). The Symmetry Grid index is: 0.90, (TBH4 4.3, p. 515). Thus, the organisation of the grid bays at length is 'just about' symmetrical and tripartite. There is no symmetry and tripartition governing the organisation of the grid along the other direction.

At the second floor there is no symmetry characterising the organisation of shapes, (TBH4 4.1, fig. 9, p. 257). The geometrical grid consists of nine geometrical bays that progress according to the following rhythm: I D L B A B F E, (TBH4 4.2, fig. 9, p. 257). At width the arrangement of the grid bays is as following: I H B A B D E. There is no overall pattern of symmetry and tripartition in either direction.

Twelve out of fourteen lines generated by the extensions of the elements of the interior at the ground floor, (12/14), coincide with the lines generated by the elements of the exterior, (I/ O Line index: 0.85), (TBH4 4.5, p. 515). The ratio of the number of lines of the interior that coincide with the existing lines defining the elements of the exterior at the first floor is four to nine, (4/9, I/O Line index: 0.44). Finally, at the second floor eleven out of thirteen lines, (11/13), defining the elements of the interior coincide with lines defining the external articulation, I/O Line index: 0.84).

- **COMPARISON ACROSS STAGES**

- **Physical properties**

At stage one the massive corners at the front of the volume at the ground and second floor interrupt the extension of the outer surface to complete the cylinder, (TBH4 4.1, fig. 1, p. 257). However, a break to the continuity of a cylindrical volume is different from a break to the continuity of the surfaces of a rectangular one. This is because the former registers as a single surface whereas the latter as an interaction of four surfaces and four corners. Thus, the former is geometrically simpler than the latter. Therefore, the apparent simplicity of the cylinder prevails over the breaks in the continuity of its contour allowing its surfaces to continue towards the definition of the largest component.

The symmetrical co-ordination of the surfaces of the cylinder on the BF axis is another factor that reinforces the hierarchical distinction of the initial solid over the rest of the components, (TBH4 4.1, fig. 1, p. 257).

At the first floor the implicit continuity of the cylinder is not interrupted by any element, (TBH4 4.1, fig. 4, p. 257). Thus, the initial solid retains its recognisability as a physical entity.

At stage two the front surface of the curvilinear element superimposed at the ground floor coincides with the surface of the cylinder, (TBH4 4.1, fig. 2, p. 257). Besides, the extended surfaces of the drum interrupt the implicit continuity of the cylindrical surface. There is no distinction between the elements of the interior and those of the exterior in terms of material or thickness of their defining surfaces.

However, only a small part of the outer surface belongs to the cylinder and to the superimposed component. Thus, each of them provides readings independent of one another. Besides, the apparent simplicity of the cylinder and the geometrical co-ordination of its surfaces by the BF and the LR axes retain the recognisability of the initial solid.

At the first floor the internal components do not share their defining lines with the lines defining the cylinder, (TBH4 4.1, fig. 5, p. 257). Thus, the physical identity of the cylinder is preserved.

Finally, at the second floor the outer surface of the cylinder coincides with the left facing surfaces of the superimposed elements, (TBH4 4.1, fig. 8, p. 257). Therefore, the same physical element defines the large and the small scale components. However, a distinction between the surfaces of these elements and the cylinder in terms of thickness of surface articulates a distinction between the large and the small scale elements.

Besides, two of the corners of the elements at the back and the front of the plan are defined by both opaque and transparent surfaces. Further, one of the corners of these elements lacks full physical definition[29]. Thus, these shapes offer simultaneous volumetric and planar readings. Thus, a distinction between thick and thin surfaces as well as between volumetric and planar readings reinforce the reading of the initial volume.

At stage three the superimposed elements at the left and the front side of the ground floor share one of their defining surfaces with the cylinder, (TBH4 4.1, fig. 3, p. 257). However, whereas the cylinder and

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29 This is because entry to these spaces is placed at these corners.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 0.66 |
| 1ST | 1 | 1 | 0.77 |
| 2ND | 0.71 | 0.72 | 0.61 |

**Table BH4 4.3** - SYMMETRY SHAPE INDEX, (BF) - No of shapes sym on BF axis/Total no of shapes

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 1 | 0.90 |
| 1ST | 1 | 1 | 0.90 |
| 2ND | 0.85 | 0.75 | 0.66 |

**Table BH4 4.4** - SYMMETRY GRID INDEX, (BF) - No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.75 | 0.83 | 0.88 |
| 1ST | 0.25 | 0.16 | 0.16 |
| 2ND | 0.62 | 0.62 | 0.62 |

**Table BH4 4.4 LR** - SYMMETRY GRID INDEX, (LR)- No of geom lines sym on LR axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 1 | 0.85 |
| 1ST | | 1 | 0.44 |
| 2ND | | 0.83 | 0.84 |

**Table BH4 4.5** - INSIDE/OUTSIDE LINE INDEX - No of geom lines of the internal and external elements/Total no of lines

the superimposed element at stage two are constantly defined by thick lines, the rest of the components are defined by both thick and thin lines. Thus, a distinction is created between the largest volume and these shapes. This preserves the hierarchical distinction of the initial solid.

At the first floor the added elements of the interior do not change the physical condition of the outer volume, (TBH4 4.1, fig. 6, p. 257). Thus, the physical identity of the initial volume is retained.

At the second floor the added elements at the right side of the plan do not affect the outer surfaces of the volume, (TBH4 4.1, fig. 9, p. 257). Thus, the organisation remains as described at stage two.

To summarise, the superimposition of shapes on the plans introduces simultaneous readings that compete with the completion of the initial volume. However, the simplicity of the cylindrical volume, the distinction of its surfaces from the surfaces of the other elements in terms of thickness and material and its overall symmetry on the BF and the LR axis contribute to its differentiation from the rest of the elements. Thus, the recognisability of the initial solid is retained throughout the stages.

- **Geometrical properties**

The shape organisation of the first floor moves from overall symmetry on the BF axis at stages one and two to 'just about' symmetry at stage three, (TBH4 4.1, fig. 4-6, p. 257, TBH4 4.3). At the ground floor the organisation of shapes changes from symmetry on the BF axis at stages one and two to asymmetry, (TBH4 4.1, fig. 1-3, p. 257, TBH4 4.3). Finally, at the second floor the 'just about' symmetrical arrangement of shapes at stage one changes to an asymmetrical organisation at stages two and three, (TBH4 4.1, fig. 7-9, p. 257, TBH4 4.3).

Thus, the properties of the interior at the first floor are close approximations of the properties of the exterior. On the other hand, the interior at the ground and second floor moves away from the symmetrical and 'just about' symmetrical organisation of the exterior. Nevertheless, certain elements like the curvilinear element at the ground floor, the void and the superimposed shape at the left side of the second floor sustain the co-ordinating role of the BF and the LR axes.

It is only at the first floor that the organisation of shapes of the interior is directed by the organisation of shapes of the exterior. However, similarly to the previous houses a discontinuity on the constant application of symmetry increases the degree of attention necessary to capture the organisation of the plan. This results in an intensification of the overall symmetrical pattern characterising the external articulation.

At the ground and first floor the grid moves from symmetry and tripartition on the BF axis at stage one and two, (TBH4 4.2 fig. 1, 2, 4, 5, p. 257, TBH4 4.4) to 'just about' symmetry and tripartition at stage three, (TBH4 4.2, fig. 3, 6, p. 257, TBH4 4.4). At the second floor the grid at length moves from 'just about' symmetry and tripartition at stage one to asymmetry at stages two and three, (TBH4 4.2, fig. 7, 8, 9, p. 257, TBH4 4.4, p. 515). Thus, at the ground and first floor the properties of the interior are close approximations of the properties of the interior.

At width it is only the ground floor grid that remains tripartite and 'just about' symmetrical throughout the stages, (TBH4 4.2, fig. 1, 2, 3, p. 257, TBH4 4.4, LR, , p. 515). The rest of the floors are not characterised by symmetry and tripartition along this direction, (TBH4 4.2, fig. 4-9, p. 257).

Looking at the relationship between the shape and the grid properties it turns out that at the first floor these properties coincide throughout the stages, (TBH4 4.3, p. 257, TBH4 4.4, p. 515). At the ground floor they coincide at stages one and two.

The I/O Line index at the ground floor drops from 1 at stage two to 0.85 at stage three, (TBH4 4.5, p. 515). At the first floor the I/O Line index changes from 1 at stage two to 0.44 at stage three. Finally, at the second floor it is approximately the same at both stages, (0.83, 0.84). Therefore, at the ground and second floor there is a large degree of coincidence between the grid lines of the former and the latter. The posistions of the eements of the interior are determined by those of the exterior showing that there is a hierarchical application of rules from the large to the small scale.

To summarise, the interior in process preserves the overall shape and grid symmetry of the exterior only at stage two at the first and second floor. Nevertheless, the deviations from symmetry expressed by 'just about' symmetry or overall asymmetry characterise only small scale elements introduced at the last stage. This allows the symmetrical organisation of the large scale elements to prevail.

- **L E C O R B U S I E R**

- **V I L L A S A V O I E A T P O I S S Y - ( L H 2 )**

- **GENERAL DESCRIPTION, (illustrations 4.21-4.24, p. 230)**

Entry to the house is on the BF axis under the floating slab. This leads to the entry hall defined by the glazed curved surface of the curvilinear volume, (illustration 4.21, p. 230). A ramp located on this axis extends the ceremonial entry to the first floor exemplifying the 'promenade architecturale', (illustration 4.23a,b, p. 230). A free standing spiral staircase is placed at the left of the ramp linking with the first floor and the roof terrace. The right, the back and the left sides of this plan, are occupied by the garage and service spaces.

The first floor plan is diagonally divided into public and private areas, (illustration 4.23b, p. 230). The former occupy the front and right side, whereas the latter the back and left side of the composition. Glazed surfaces in the sitting room create a continuity between the inside and the outside space, (illustration 4.24, p. 230). This continuity is asserted by the uninterrupted extension of the outer surface along the terrace.

Two bedrooms occupy the left side of the plan, while a third one extends from the back of the house to the spiral staircase at the centre of the composition. The functional accessories inside these spaces become sculptural incidents resulting in an intricate articulation of the local scale. Similarly to LH1 the absence of separating boundaries at the public areas suggests a spatial flow. On the other hand, the private areas consist of separate rooms strictly enclosed within their defining surfaces.

- **DESCRIPTION OF STAGES**

Volumetric analysis suggested that at stage one the ground floor is symmetrical on the BF axis in terms of both shape and grid properties, (TLH2 4.1, fig. 1, TLH2 4.2, fig. 1, p. 284). The grid bays at length progress according to the following sequence: C B A B C, (TLH2 4.2, fig. 1, p. 284). This is a symmetrical and tripartite pattern. At width there is no symmetry and tripartition.

The first floor plan is not characterised by shape or grid symmetry on any of the two axes, (TLH2 4.1, fig. 4, TLH2 4.2, fig. 4, p. 284). The sequence of the grid bays at length is as following: C D F F G D. At width the grid bays are organised on a E J J E H B D F sequence.

At stage two the vertical support elements and a spiral staircase are added in both floor plans, (TLH2 4.1, fig. 2, 5, p. 284). The changes occurring at the ground floor concern with the addition of the ramp as well as with the superimposition of three elements, (TLH2 4.1, fig. 2, p. 284). These shapes share their outer surfaces with the defining surfaces of the curvilinear volume.

A spiral staircase is added at the left side of the first floor, (TLH2 4.1, fig. 5, p. 284). Besides, six elements are superimposed at the front, left and back side of the plan. These elements share their defining elements with the outer surfaces of the volumetric rectangle.

At the ground floor it is only the ramp that is placed on the BF axis, (TLH2 4.1, fig. 2, p. 284). The rest of the components are not covered by any of the axes of the block. There is no overall shape symmetry characterising any of the ground and first floors. The arrangement of the grid bays at length at the ground floor is as following: C B J F F F G B C, (TLH2 4.2, fig. 2, p. 284). The Symmetry Grid index is 0.83, (TLH2 4.5, p. 502). Thus, the organisation of the grid bays is 'just about' symmetrical and tripartite. At width the sequence of the grid bays progresses according to a F J K B I pattern. This is not a symmetrical and tripartite arrangement.

At the first floor the sequence of the grid bays progresses at length as follows: C H H H H G F F G D, (TLH2 4.2, fig. 5, p. 284). This is not a symmetrical and tripartite pattern. At width the grid bays are organised according to a E J F F F D F H L H D F rhythm. There is no symmetry or tripartition in this arrangement either.

The sequence of the geometrical bays of the structural grid progresses at length as following: D D D D, (TLH2 4.3, fig. 1,3, p. 285). At width the sequence of the bays is: F D D D D F. These are both symmetrical patterns.

At the ground floor an association is constructed between the two grids at length based on the 'just about' symmetrical organisation of the physical and the symmetrical organisation of the structural grid, (TLH2 4.2, fig. 2, p. 284, TLH2 4.3, fig. 1, p. 285). However, there is no tripartition characterising the organisation of the structural grid. Thus, although symmetry underlies both grids the distinction of the central geometrical bay from the rest of the bays of the physical grid is contrasted by the equal spacing of the structural bays. There is no association characterising the properties of the two grids at width.

Looking at the relationship between the two grids at the first floor it turns out that there is no association characterising the properties of the physical and those of the structural grids in either of the two directions, (TLH2 4.2, fig. 5, p. 284, TLH2 4.3, fig. 3, p. 285).

At the ground floor five out of fifteen lines, (5/15), generated by the elements of the interior coincide with the lines generated by the elements of the exterior, (I/O Line index: 0.33), (TLH2 4.5, p. 522). At the first floor ten out of twenty lines, (10/20), defining the shapes of the interior coincide with the lines defining the shapes of the exterior, (I/O Line index: 0.50).

At stage three two rectangles are superimposed at the left side of the ground floor, (TLH2 4.1, fig. 3, p. 284). Besides, a trapezoid is superimposed at the back right corner of the composition. There are also changes altering the position of particular support elements. Thus, the central column and the ones on its either side of the second and third row of columns from the back of the plan are moved to new positions. Besides, the central column of the fourth row from the back is eliminated and replaced by two columns symmetrically placed on the BF axis on the lines generated by the extensions of the lines defining the ramp.

A new shape is superimposed at the first floor stretching from the back of the plan to the spiral staircase, (TLH2 4.1, fig. 6, p. 284). A rectangle is superimposed on this shape at the back of the staircase. A second rectangle of similar proportions is superimposed on the shape at the centre of the left side of the plan. Other changes occurring at this plan concern with the addition of a solid component in each of the three superimposed elements occupying the left and the back side of the plan as well as in the superimposed shape in between the superimposed shapes at the front of the composition. They also concern with modifications of the structural grid in a manner similar to the one occurring at the ground floor.

There is no shape symmetry characterising the arrangement of shapes in both plans, (TLH2 4.1, fig. 3, 6, p. 284). At the ground floor there are no changes regarding the sequence of the grid bays at length, (TLH2 4.2, fig. 3, p. 284). Thus, the organisation of the grid along this direction remains 'just about' symmetrical and tripartite as described at stage two. At width the grid bays progress according to a F J J G L B B I rhythm. This is an asymmetrical and non-tripartite organisation.

At the first floor the grid bays at length progress according to the following rhythm: C H H H H H H L B F F G D, (TLH2 4.2, fig. 6, p. 284). This is not a symmetrical and tripartite organisation. At width the arrangement of the grid bays is as following: F J M F F F F F F H L H D F. This is not a symmetrical and tripartite pattern either.

The geometrical bays of the structural grid progress at length according to the following sequence: D C F F C D, (TLH2 4.3, fig. 2, 4, p. 285). This is a symmetrical and tripartite organisation. At width they are arranged as following: F J L L H L C B J B D F. There is no symmetry and tripartition characterising this organisation.

Looking at the relationship between the physical and the structural grid at length it turns out that at the ground floor there is a coincidence between the properties of these grids, (TLH2 4.2 fig. 3, p. 284, TLH2 4.3, fig. 2, p. 285). This is based on 'just about' symmetrical and tripartite organisation of the physical grid and the symmetrical organisation of the structural grid. There is no association between the two grids at width. Besides, there is no association between these grids at the first floor in either of the two directions, (TLH2 4.2, fig. 6, p. 284, TLH2 4.3, fig. 4, p. 285).

At the ground floor seven out of twenty lines, (7/20), generated by the elements of the interior coincide with the lines generated by the elements of the exterior, (I/O Line index: 0.35), (TLH2 4.5, p. 522). At the first floor this ratio is 15/28, (I/O Line index: 0.53).

- **COMPARISON ACROSS STAGES**

- **Physical properties.**

At stage one the curvilinear volume at the ground floor is defined by both glazed and transparent material, (TLH2 4.1, fig. 1, p. 284). Although there is no uniformity of contour, the continuity of the curvilinear surface and its ability to read as a single boundary preserves its coherence as a volumetric entity.

The L shaped element at the first floor interlocks with the L shaped terrace and the longitudinal void occupied by the ramp, (TLH2 4.1, fig. 4, p. 284). The interlocking relation among these elements creates conflicting readings that reduce their volumetric clarity.

Further, these shapes share their defining elements with the defining surfaces of the largest rectangle. In Volumetric Analysis it was suggested that the volumetric definition of this rectangle is based on a planar decomposition of the L. Thus, at this stage the volumetric components complement each other in defiance of their explicitness as coherent shapes.

However, whereas the rectangle is defined by opaque surfaces, the L and the void are defined by both opaque and transparent surfaces. Thus, the distribution of material along the surfaces of these elements creates a distinction between the volumetric rectangle and the rest of the components. Nevertheless, the surfaces travelling in front of the open space register as planes. Thus, regardless of their uniformity their planar character challenges the volumetric coherence of the largest volume.

At stage two the superimposed shapes at the ground floor share their defining surfaces with the curvilinear volume, (TLH2 4.1, fig. 3, p. 284). All shapes are defined by both thick and thin surfaces as well as by transparent and opaque material. Therefoe, differences in material and in thickness of defining surface does not clarify the distinction between the defining elements of the large and the small scale components.

Besides, certain corners of these elements are defined by both glazed and opaque surfaces. Thus, an analysis of these shapes into planar constituents undermines their volumetric clarity further.

At the first floor the superimposed shapes increase the complexity of the configuration sharing their defining elements with the defining elements of the rectangle and the volumetric L, (TLH2 4.1, fig. 5, p. 284). Similarly to the ground floor, both thick and thin surfaces, opaque and transparent material define the large and the small scale components. Thus the material articulation does not clarify, from a first point of view, the relations amongst these elements.

This coupled to the ambiguities existing in the relation amongst the largest rectangle, the L and the terraces increases the conflicts between the large and the small scale elements. It is only the uniform treatment of the outer surfaces that restores to a certain extent the definition of the largest rectangle.

At stage three more complicated patterns of interaction are created amongst the elements of the large and the small scale articulation at both the ground and the first floor, (TLH2 4.1, fig. 3, 6, p. 284). This is because the largest components and the superimposed elements share their defining surfaces. At the ground floor the portion of the curvilinear surface defined by opaque material is increased, (TLH2 4.1, fig. 3, 6, p. 284). Thus, the uniformity of its contour is undermined further.

At the first floor the small scale interacts with the large one in a manner similar to the one described at stage two, (TLH2 4.1, fig. 6, p. 284). Further, the new configuration comprises a series of interlocking shapes that produce simultaneous readings. The interlock produced amongst the elements of the interior coupled with that amongst the elements of the exterior increase the degree of difficulty in capturing the physical organisation of the configuration.

- **Geometrical properties.**

The organisation of shapes at the ground floor moves from overall symmetry at stage one to asymmetry at stages two and three, (TLH2 4.1, fig. 1-3, p. 284, p. 284). Thus, a dissociation is constructed between the symmetrical exterior and the asymmetrical interior. There is no overall symmetry characterising the organisation of shapes at the first floor in any stage, (TLH2 4.1, fig. 4-6, p. 284).

Volumetric analysis suggested that at the first floor only the organisation of the largest scale component is characterised by overall shape symmetry, (TLH2 3.2, fig. 7-8, p. 198). Thus, at this level the dissociation between the properties of the last stage and the properties of the first stages observed at the analysis of the exterior is continued by the articulation of the interior.

The ground floor grid moves from overall symmetry and tripartition at length to 'just about' symmetry and tripartition at the following stages, (TLH2 4.2, fig. 1-3, p. 284, TLH2 4.4, p. 522). In this respect, the properties of the internal organisation are close approximations of those of the external organisation. At width there is no symmetry and tripartition in any stage.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.83 | 0.79 |
| 1ST | 0.71 | 0.63 | 0.50 |

Table **LH2 4.4**
**SYMMETRY GRID INDEX, (BF)** - No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.66 | 0.37 | 0.33 |
| 1ST | 0.66 | 0.30 | 0.66 |

Table **LH2 4.4 LR**
**SYMMETRY GRID INDEX, (LR)** - No of geom lines sym on LR axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.33 | 0.35 |
| 1ST | | 0.50 | 0.53 |

Table **LH2 4.5**
**INSIDE/OUTSIDE LINE INDEX** - No of geom lines of internal and external elements/Total no of lines

The organisation of the grid bays at the first floor moves from 'just about' symmetry to asymmetry in both stages two and three, (TLH2 4.2, fig. 4-6, p. 284). At width there is no symmetry and tripartition governing the grid organisation in any stage.

At the ground floor there is a dissociation between the shape and the grid properties throughout the stages expressed by an opposition between the asymmetrical organisation of shapes and the 'just about' symmetrical organisation of the lines that these shapes generate, (TLH2 4.1, fig. 1-3, p. 284, TLH2 4.4). Thus, the interior of this floor substitutes the obvious symmetries of the shape organisation for hidden symmetries of the grid.

In both stages two and three the geometrical properties of the structural grid at length at the ground floor coincides with the properties of the physical grid, (TLH2 4.2, fig. 2-3, p. 284, TLH2 4.3, fig. 1-2, p. 285). At stage three the adjustments produced by the repositioning of certain columns introduce tripartition to the structural grid. This strengthens the relations between the two grids. It also strengthens the co-co-ordinating role of the BF axis and of the central geometrical bay.

Besides, the majority of the lines of the structural grid at stage three coincide with the lines of the physical grid. The only exception is the lines connecting the second row of columns from the front and the third row of columns from the back at the ground floor, (TLH2 4.2, fig. 3, p. 284), and the line connecting the central columns at the left and right sides of the first floor, (TLH2 4.2, fig. 6, p. 284).

At the first floor a dissociation is constructed between the symmetrical and tripartite structure of the structural grid at length and the asymmetrical structure of the physical grid, (TLH2 4.2, fig. 4-5, p. 284, TLH2 4.3, fig. 4-5, p. 285). Therefore, the two grids are treated as independent systems.

There are no major changes to the I/O Line index from stage two to stage three. At the ground floor it moves from 0.33 to 0.35, (TLH2 4.5), whereas at the first floor from 0.50 to 0.53. These low values indicate that there is no extensive coincidence between the elements of the exterior and the elements of the interior. There are no overall rules applied from the external to the internal ordering determining the positions of the internal partitions on the plan.

To summarise, the interior in process moves away from the overall shape symmetry of the largest volumetric components that constitute the external organisation of the building. However, the symmetries of the figurative appearance at the ground floor are replaced by subtler symmetries of the grid. Nevertheless, a lack of coincidence between the lines of the interior and those of the exterior does not give physical definition to the geometrical grid. The grid appears hidden behind the asymmetrical arrangement of shapes.

- V I L L A  M E Y E R - ( L H 3 )

- **GENERAL DESCRIPTION, (illustrations 4.25-4.28, p. 232)**

Entry to the house is through a terrace that cuts deeply inside the volume. Two staircases and a circular space are situated at the middle of the ground floor, (illustration 4.27b, p. 232). These spaces are treated as sculptural entities the curved surfaces of which protrude into the surrounding space. Their clear demarcation by enclosing boundaries contrasts the flowing public space. A ramp placed against the right surface of the volume forms also a vertical link with the floor above.

This ramp reaches a gallery space at the first floor overlooking the sitting area below, (illustration 4.27a, p. 232). The two staircases divide this plan into two bedrooms and a bathroom placed at the left and a bedroom with a bathroom placed at the right of the composition,. A strong sculptural character is given to the surfaces of these rooms to accommodate small items of the programme.

At the ground floor the enclosed rooms read as 'islands' inside the flowing space of the L shaped interior, (illustration 4.26, p. 232). On the other hand, at the first floor the complexity of interpenetrating rooms creates a 'jig - saw' effect that offers no clear perception of the space enclosed by the outer surfaces, (illustration 4.27a, p. 232).

- **DESCRIPTION OF STAGES**

The largest volumetric component describing this house is a cube that is excavated to define a volumetric L at both the ground and first floor. Overall shape and grid symmetry on the diagonal axis of the block characterises these plans, (TLH3 4.1, fig. 1, 4, p. 286, TLH3 4.4, diagonal axis, p. 527). The organisation of the ground floor grid at length is based on the sequence: A A C. At width the grid bays progress as following: C E C. Therefore, there is overall symmetry characterising the grid organisation form back to front. The same symmetrical and tripartite arrangement organises the grid of the first floor at width. On the other hand, there is no symmetry and tripartition along the left to right direction in any floor.

At stage two a ramp is added at the right side of the ground and first floor, (TLH3 4.1, fig. 2, 5, p. 286). The structural support elements are also introduced in both floor plans. Further, two curvilinear elements each of which contains a staircase are superimposed on the ground floor. The surface of one of these elements coincides with the front facing surface of the volumetric L and the void. Finally, two curvilinear elements defining the staircases are added at the first floor.

There is no overall symmetry governing the distribution of shapes in any floor, (TLH3 4.1, fig. 2, 5, p. 286). The ground floor geometrical bays progress at width according to the following rhythm: B H A D, (TLH3 4.2, fig. 2, p. 286). This is not a symmetrical and tripartite organisation.

At width the arrangement of the grid bays is as following: D F F E H H E C. This is a not a symmetrical and tripartite pattern either. However, if the six geometrical bays at the back of the composition are joint into a single one, then the arrangement of the grid lines becomes: C E C. Thus, a symmetrical and tripartite pattern is incorporated into the asymmetrical structure of the grid. There is no symmetry of the grid bays on the diagonal axis of the block, (TLH3 4.4, Diagonal axis, p. 527).

At the first floor the grid bays progress at length according to thesequence: J F E A D, (TLH3 4.2 fig. 5, p. 286). This is not a symmetrical and tripartite organisation. The sequence of the grid bays at width is as following: D F F E H H E C, (TLH3 4.2, fig. 5, p. 286). This is not a symmetrical and tripartite pattern. However, if the second and the fifth line are omitted the arrangement of the bays becomes: C E C. Thus, a symmetrical and tripartite pattern is incorporated in the asymmetrical organisation of the grid.

Besides, half of the grid lines are symmetrical on the diagonal axis of the block, (7/14), (TLH3 4.4, diagonal axis, p. 507). Thus, although there is no overall symmetry on this axis, local symmetries are created that reinforce its co-ordinating role.

The structural grid consists of four geometrical bays at length that are organised according to the following sequence: A A A D, (TLH3 4.3, fig. 1, 3, p. 287). At width the arrangement of the grid bays is as following: D M E C. None of these patterns is characterised by symmetry and tripartition.

Four out of eleven lines, (4/11), defining the elements of the internal articulation at the ground floor coincide with lines defining the elements of the external articulation, (I/O Line index: 0.36), (TLH3 4.5, p. 527). At the first floor this ratio is 4/13, (I/O Line index: 0.30).

At stage three a cylindrical component is superimposed on the ground floor plan, (TLH3 4.1, fig. 3, p. 286). Further, an L shaped partition is added inside the sitting area, while two other partitions are attached to the external surface of the staircase superimposed at stage two. Besides, five volumetric components are superimposed on the first floor plan, (TLH3 4.1, fig. 6, p. 286). One at least surface of the large shapes coincides with an outer surface of the block.

There is no overall shape symmetry governing the disposition of shapes in any floor, (TLH3 4.1, fig. 3, 6, p. 286). The sequence of the grid bays at length at the ground floor progresses according to the rhythm: B H D I D, (TLH3 4.2, fig. 3, p. 286). This is not a symmetrical and tripartite pattern. At width the arrangement of the grid bays remains as defined at the previous stage, (TLH3 4.2, fig. 2, p. 286).

Thus, no symmetry or tripartition govern the organisation of the grid along this direction. Nevertheless, the symmetrical and tripartite pattern embedded into the grid at stage two is retained.

At the first floor the arrangement of the grid bays progresses at length as following: G D E K H H E K E D, (TLH3 4.2, fig. 6, p. 286). This is not a symmetrical and tripartite organisation. Nevertheless, the third and the ninth, the fourth and the eight lines from the left are symmetrical to each other with respect to the BF axis. Thus, the local symmetries embedded in the grid organisation at stage two are reinforced by the addition of four more geometrical lines that are symmetrical on the BF axis.

The organisation of the grid bays at width is based on the following rhythm: F F F F F H H H L C. This pattern is not characterised by symmetry or tripartition. However, similarly to stage two the C E C sequence incorporated into the grid is retained.

Besides, four out of thirteen, (4/13), lines at the ground floor generated by the extensions of the elements of the internal articulation coincide with the lines defining the components of the external articulation, (I/O Line index: 0.30, TLH3 5.5, p. 527). At the first floor five out of twenty five lines, (5/25),of the internal articulation coincide with lines of the external articulation, (I/O line index: 0.20).

- **DESCRIPTION ACROSS STAGES**

- **Physical properties**

Volumetric analysis suggested that the planar definition of the left side of the block at stage one decomposes both the block and the volumetric L into volumetric and planar components, (TLH3 4.1, fig. 1, p. 286). Looking at the ways the distribution of material along the contour of these elements contributes to their physical articulation, it turns out that in both floors the surfaces of the block, the volumetric U and the void are defined by both transparent and opaque material. Thus, there is no distinction amongst these components based on a distinction of defining materials.

Besides, the left back and front corners of the block in both floors are defined by both transparent and opaque surfaces, whereas its right corners are defined by opaque surfaces only. Further, all apart from the left back and front corners of the volumetric L are defined by opaque and transparent surfaces. Finally, all corners of the void are defined by both opaque and transparent material.

Thus, the material definition of these volumes does not restore the planar decomposition of the cube produced by the extension of its left surface at stage four of the Volumetric analysis, (TLH3 3.1, fig. 4, p. 200). On the contrary, it decomposes them further into volumetric and planar constituents.

At stage two the superimposed curvilinear volume and the ramp added at the ground and first floor plans share one of their defining surfaces with the surfaces of the volumetric L, (TLH3 4.1, fig. 2, 5, p. 286). Thus, the same surfaces provide simultaneous readings of the large and the small scale elements. However, a distinction between thick and thin surfaces articulates a distinction between the new elements and the existing ones.

At stage three the superimposed element at the ground floor does not share any of its defining elements with the surfaces of the block and the volumetric L, (TLH3 4.1, fig. 3, p. 286). Thus, there are no changes introduced to the physical properties of these elements.

On the other hand, at the first floor the block and three of the superimposed shapes are simultaneously defined by the same surfaces, (TLH3 4.1, fig. 6, p. 286). However, a distinction between thick and thin lines establishes a distinction between the large and the small scale.

Nevertheless, certain corners of the superimposed shapes are defined by both opaque and transparent surfaces. Thus, a decomposition of these elements takes place that analyses them into a network of straight and curved surfaces. Shape readings and linear readings interact denying any clear distinction amongst the elements of the small scale.

Besides, the jig-saw relations amongst these shapes increases the difficulty to understand them as clear and separate entities. Thus, whereas at the first floor the conflict stays mainly at the level of the relationship between the block, the volumetric L and the void, at this floor it expands at the level of the relations amongst the large and the small scale components as well as amongst the small scale components themselves.

To summarise, the decomposition of the volume created at the level of the external appearance of the house is extended by the material distribution along the surfaces of the large and the small scale components. Looking at these plans one finds impossible to achieve a single reading produced by the hierarchical distinction of a single element or of a category of elements over the rest of the components.

- **Geometrical properties**

The geometrical properties of the shapes of both ground and first floor are not governed by symmetry with respect to any of the axes of the block in any stage, (TLH3 4.1, fig. 1-6, p. 286). Thus, a dissociation is created between the shape properties of the first stage and those of the other stages. This is based on a contrast between the symmetrical organisation of the former on the diagonal axis and an asymmetrical organisation of the latter. There is no association between the properties of the exterior and those of the interior.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.50 | 0.40 | 0.50 |
| 1ST | 0.66 | 0.66 | 0.66 |

Table **LH3 4.4**

**SYMMETRY GRID INDEX, (BF)** - No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.44 | 0.44 |
| 1ST | 1 | 0.55 | 0.53 |

Table **LH3 4.4 LR**

**SYMMETRY GRID INDEX, (LR)** - No of geom lines sym on LR axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 1 | 0.50 | 0.50 |
| 1ST | 1 | 0.50 | 0.54 |

Table **LH3 4.4 Diag axis**

**SYMMETRY GRID INDEX, (diag axis)** - No of geom lines sym on diag axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.36 | 0.30 |
| 1ST | | 0.30 | 0.20 |

Table **LH3 4.5**

**INSIDE/OUTSIDE LINE INDEX** - No of geom lines of internal and external elements/Total no of lines

There is no symmetry governing the organisation of the grid bays in either direction at both stages two and three, (TLH3 4.2, fig. 2, 3, 5, 6, p. 286). Thus, the symmetrical organisation of the grid bays on the LR and on the diagonal axis at stage one is contrasted with the asymmetrical organisation of the grid of the interior. Nevertheless, local symmetries are articulated reinforcing the diagonal as well as both the BF and the LR axis..

There is no association between the structural and the physical grid either, (TLH3 4.2, fig. 2, 3, 5, 6, p. 286, TLH3 4.3, fig. 1, 2, 3, 4, p. 287). This is because there is no connection between the irregular arrangement of the physical bays and the regular spacing of the bays of the structural grid. However, all lines of the structural grid coincide with a line of the physical grid[30]. This shows that although the two grids are treated as independent logical systems, they physically coincide.

The I/O index at the ground floor drops from 0.36 at stage two to 0.30 at stage three, (TLH3 4.5). At the first floor it also drops from 0.30 to 0.20. Thus, there is no extensive application of rules from the external to the internal organisation determining coincidence amongst the lines defining the former and those defining the latter.

To summarise, the interior in process contrasts the overall symmetry on the diagonal axis characterising the first stages of the Volumetric Analysis. However, symmetrical patterns are embedded into the grids with respect to all axes. Nevertheless, a lack of coincidence between the lines of the exterior and those of the interior results in a lack of physical definition of the grid system. The grid network with its incorporated patterns of symmetry remains hidden behind the complex network of interpenetrating shapes. Thus, the extensions of lines have to be drawn to allow the geometry of the plan to become visible.

However, even when these lines are extended the simultaneous application and negation of symmetry expressed through the symmetrical patterns embedded into the asymmetrical ones does not allow an immediate understanding of the geometrical logic of the plans.

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30 The only exception is the second line from left in both floors, (TLH3 4.2, fig. 2, 5, p. 286).

- VILLA BAIZEAU-(LH4)

- **GENERAL DESCRIPTION, (illustrations 4.29-4.32, p. 233)**

Access to this house is through the pilotis that elevates the front part of the volume from the ground, (illustration 4.31c, p. 233). An entry door situated off the BF axis leads to the entry hall. An L shaped staircase also situated off axis leads to the floors above. The back of the ground floor accommodates the service spaces.

The staircase divides the first and second floors into public areas located at the front and private ones located at the back of the plan, (illustration 4.31b, p. 233). At the first floor the staircase is enclosed inside a glass volume that protrudes into the terrace at the left,.

At the second floor the public area becomes a gallery space that overlooks the first floor below, (illustrations 4.29, p. 233). The back part of this plan is divided into three bedrooms. At the third floor the public space is also a gallery that is vertically linked through a void with the second floor, (illustration 4.30, p. 233). Three mezzanines each of which is connected with a bedroom below are located at the back of the plan.

- **DESCRIPTION OF STAGES**

Volumetric analysis suggested that there is no shape and grid symmetry governing the organisation of the ground and first floor at stage one, (TLH4 4.1, fig. 1, 4, p. 288, TLH4 4.2, fig. 1, 4, p. 289). On the other hand the second floor is characterised by symmetry on the BF and LR axis, (TLH4 4.1, fig. 7, 10, p. 288, TLH4 4.2, fig. 7, 10, p. 289).

At stage two the structural grid and the staircase are added in all floor plans, (TLH4 4.1, fig. 2, 5, 8, 11, p. 288). At the ground floor five shapes are superimposed on the plan, (TLH4 4.1, fig. 2, p. 288). These elements share their defining surfaces with the outer surfaces of the block.

Seven shapes are superimposed on the first floor plan, (TLH4 4.1, fig. 5, p. 288). These elements also share their defining surfaces with the surfaces of the block. Besides, four of these shapes extend in height occupying the right part of the second floor plan.

The changes occurring at the second floor concern with the superimposition of a L and two rectangles at the left side of the plan, (TLH4 4.1, fig. 8, p. 288). These shapes are also defined by the outer surfaces of the block. Further, they extend in height occupying the left bottom part of the third floor. Finally, at the third floor a void is created linking this floor with the floor below, (TLH4 4.1, fig. 11, p. 288).

There is no overall symmetry governing the disposition of shapes in any floor, (TLH4 4.1, fig. 2, 5, 8, 11, p. 288). The ground floor grid bays progress at length according to the following sequence: B A H B D, (TLH4 4.2, fig. 2, p. 289). This is not a symmetrical and tripartite organisation. At width the organisation of the grid bays is as following: D D I H B B B D C. The Symmetry Grid index is 0.70, (TLH4 4.4 LR, p. 532). Thus, the organisation of the gird bays is 'just about' symmetrical and tripartite.

At the first floor the grid bays at length are organised according to a rhythm: B D B B A, (TLH4 4.2, fig. 5, p. 289). The Symmetry Grid index is: 0.83, (TLH4 4.4, p. 532). Thus, the pattern of the grid bays at length is characterised by 'just about' symmetry and tripartition. At width the organisation of the grid bays progresses as following: D B A D H H H E C. This is not a symmetrical and tripartite organisation.

At the second floor the grid bays are arranged at length according to the following sequence: B D B B A, (TLH4 4.2, fig. 8, p. 289). This is a not a symmetrical and tripartite organisation. However, the Symmetry Grid index is 0.83, (TLH4 4.4, p. 532). Thus, the organisation of the grid bays is 'just about' symmetrical and tripartite.

At width the organisation of the grid is based on the following sequence: B B B B F I H H H D C. This is not a symmetrical and tripartite organisation. However, the two lines flanking the central geometrical line and the fifth and eleventh line from the back enter into symmetrical and tripartite relations. This shows that symmetrical and tripartite patterns are embedded into the asymmetrical organisation of the grid at width.

At the third floor the grid at width is organised according to the rhythm: A F A, (TLH4 4.2, fig. 11, p. 289). This is a symmetrical and tripartite arrangement. At width the organisation of the grid bays progresses as following: D D A H H H K. This is not a symmetrical and tripartite pattern.

The structural grid at length is symmetrical and tripartite progressing according to the following sequence: B A A B, (TLH4 4.3, fig. 1, 3, 5, 7, p. 290). At width only symmetry characterises the organisation of the grid bays based on the following pattern: C C C C.

At the ground floor three out of fourteen lines, (3/14),of the interior coincide with lines defining the elements of the external articulation, (I/O Line index: 0.21), (TLH4 4.5, p. 532). This ratio at the first, second and third floor is : 0.60, 0,17 and 0.10 respectively.

At stage three the rectangles superimposed at stage two at the back and the left side of the ground floor plan are subdivided into three superimposed rectangles, (TLH4 4.1, fig. 3, p. 288). At the first floor two elements are superimposed on the second rectangle from the back of the composition superimposed at stage two, (TLH4 4.1, fig. 6, p. 288). The changes occuring at the second floor concern with the superimposition of a rectangle on each of the shapes superimposed at the left side of the composition at stage two, (TLH4 4.1, fig. 9, p. 288). Finally, at the third floor three mezanines are added inside the shapes superimposed at the back of the plan at stage two, (TLH4 4.1, fig. 12, p. 288).

There is no symmetrical disposition of shapes in any floor, (TLH4 4.1, fig. 3, 6, 9, 12, p. 288). The ground floor grid is organised at length according to the following sequence: B H L H B L M H M F, (TLH4 4.2, fig. 3, p. 289). This is not a symmetrical and tripartite pattern. At width the grid bays progress according to the following rhythm: I H I B I H B B B D C. This is not a symmetrical and tripartite pattern either.

At the first floor the grid bays at length are arranged according to a B I B B B B F sequence, (TLH4 4.2, fig. 6, p. 289). This is not characterised by symmetry and tripartition. At width the grid bays progress as following: D B D B D H H H F C. This is not a symmetrical and tripartite organisation either.

At the second floor the grid bays progress at length according to the rhythm: B D B B B F, (TLH4 4.2, fig. 8, p. 289). This is not a symmetrical and tripartite organisation. However, the Symmetry Grid index is 0.71, (TLH4 4.4, p. 532). Thus, the grid organisation is 'just about' symmetrical and tripartite. At width the arrangement of the grid bays is as follows: B B B B L M I H H H D C. This is not a symmetrical and tripartite organisation.

At the third floor the sequence of the grid bays progresses at length as following: D B B D, (TLH4 4.2, fig. 12, p. 289). This is a symmetrical and tripartite arrangement. At width the organisation of the grid bays is as following: D D A H H H K. This is not a symmetrical and tripartite pattern.

At the ground floor the I/O line index is 0.15, (TLH4 4.5, p. 532). At the first, second and third floor this index is : 0.50, 0.15 and 0.30 respectively.

- **COMPARISON ACROSS STAGES**

- **Physical properties**

At stage one the largest component at the ground floor is a L, (TLH4 4.1, fig. 1, p. 288). The surfaces of this shape are defined by both opaque and transparent material. The back left and right corners of this elements are defined by both transparent and opaque material, while the front ones are defined by opaque material only. There is a lack of uniform physical definition which together with the planar decomposition of the back corners contradict the volumetric identity of this element.

At the first floor the largest component is a rectangle to which a curvilinear and a smaller rectangle are attached, (TLH4 4.1, fig. 5, p. 288). The surfaces of this volume are defined by both opaque and transparent material. A lack of uniform contour and a planar decomposition of its four corners characterises this element destroying its volumetric character.

At the second floor the back corners of the rectangle provide volumetric readings, whereas the front ones are decomposed into opaque and transparent planes, (TLH4 4.1, fig. 9, p. 288). Thus, this element does not retain its volumetric clarity either.

Finally at the third floor it is only the back left corner of the rectangle that has volumetric definition, (TLH4 4.1, fig. 12, p. 288). The rest of the corners are analysed into opaque and transparent planes.

At stage two and three the simultaneous definition of the superimposed elements and the L at the ground floor by the same defining surfaces introduces simultaneous readings of the large and the small scale components, (TLH4 4.1, fig. 2, 3, p. 288). Nevertheless, a distinction between thick and thin surfaces clarifies the relationship between these elements.

At the first floor the same distinction distinguishes between the rectangle and the rest of the components, (TLH4 4.1, fig. 5, 6, p. 288). However, the interruption of the implicit continuity of the glazed surface of the rectangle at the left by the opaque surfaces of the staircase interrupts the extension of these surfaces to complete its contour.

Besides, one at least corner of the superimposed elements is analysed into planes based on its physical definition by opaque and transparent surfaces, or on the lack of full physical definition created by a door entry. The elements of the interior are also analysed into a system of interacting volumetric and planar components. This increases the complexity of the configuration further. Thus, there is no clear distinction between the large and small scale components apart from a distinction of thickness of defining surfaces.

At the second floor the superimposed elements are given volumetric definition, (TLH4 4.1, fig. 8, 9, p. 288). Thus, they are basically understood as volumetric elements distinguished from the rectangle by the thickness of their defining surfaces. Finally at the third floor the superimposed shapes are decomposed into planar and volumetric components also distinguished from the external planes by the thickness of their defining surfaces, (TLH4 4.1, fig. 11, 12, p. 288).

Thus, it seems that there is no clear distinction between the largest and smallest elements apart from the thickness of their contour. The planar decomposition of all shapes creates a network of interacting volumes and planes none of which registers clearly towards one description.

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.66 | 0.50 | 0.45 |
| 1ST | 0.50 | 0.83 | 0.62 |
| 2ND | 1 | 0.83 | 0.71 |
| 3RD | 0.66 | 1 | 1 |

Table **LH4 4.4**
**SYMMETRY GRID INDEX, (BF)**- No of geom lines sym on BF axis/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | 0.66 | 0.70 | 0.58 |
| 1ST | 0.50 | 0.30 | 0.36 |
| 2ND | 1 | 0.58 | 0.50 |
| 3RD | 0.50 | 0.37 | 0.37 |

Table **LH4 4.4 LR**
**SYMMETRY GRID INDEX, (LR)** - No of geom lines of internal and external elements/Total no of lines

| STAGE | 1 | 2 | 3 |
|---|---|---|---|
| GR | | 0.21 | 0.15 |
| 1ST | | 0.60 | 0.50 |
| 2ND | | 0.17 | 0.15 |
| 3RD | | 0.10 | 0.30 |

Table **LH4 4.5**
**INSIDE/OUTSIDE LINE INDEX** - No of geom lines of internal and external elements/Total no of lines

- **Geometrical properties**

Analysis of the geometrical properties showed that there is no shape symmetry characterising the organisation of any of the floor plans, (TLH4 4.1, fig. 1-12, p. 288). Thus, the absence of overall symmetry characterises both the internal and the external organisation.

At the ground floor the organisation of the grid bays is not characterised by symmetry and tripartition at length in any stage, (TLH4 4.2, fig. 1, 2, 3, p. 289). At width the grid organisation moves from overall asymmetry at stage one to 'just about' symmetry at stage two and overall asymmetry at stage three, (TLH4 4.4, LR). Thus, there is no systematic development of properties along the analytic stages.

At the first floor the grid at length moves from asymmetry at stage one to 'just about' symmetry and tripartition at stage two and to asymmetry at stage three, (TLH4 4.2, fig. 4, 5, 6, p. 289, TLH4 4.4). Therefore, there is no consistent pattern of relations amongst the properties of each stage with those of the previous one. There is no consistent pattern of relations between the properties of the interior and those of the exterior either. At width there is no symmetry and tripartition in any stage.

At the second floor the grid moves from overall symmetry at length at stage one to 'just about' symmetry and tripartition at stage two and three, (TLH4 4.2, fig. 7, 8, 9, p. 289, TLH4 4.4). Thus, the geometrical properties of the interior coincide with those of the exterior. At width the organisation of the grid bays changes from overall symmetry at stage one to asymmetry at stages two and three, (TLH4 4.2, fig. 7, 8, 9, p. 289, TLH4 5.4 LR). Therefore, a contrast is created between a symmetrical exterior and an asymmetrical interior along this direction.

Finally, at the third floor the grid at length progresses from overall asymmetry at stage one to overall symmetry at stages two and three, (TLH4 4.2, fig. 10, 11, 12, p. 289, TLH4 4.4). A contrast is created between the internal and the external grid organisation. This is based on an asymmetrical grid of the exterior and a symmetrical grid of the interior at length. At width the grid stays asymmetrical throughout the stages, (TLH4 4.2, fig. 10, 11, 12, p. 289, TLH4 4.4 LR).

Looking at the relationship between the shape and the grid organisation it turns out that at the first, second and third floor at stage two a contrast is constructed between the asymmetrical organisation of shapes and the 'just about' symmetrical organisation of grid bays at length, (TLH4 4.4). At stage three the same contrast operates at the second and third floor.

Besides, the asymmetrical arrangement of shapes at the ground floor is challenged by the 'just about' symmetrical organisation the grid at width at stage two, (TLH4 4.4, LR). Thus, at these floors the observable shape symmetries are replaced by subtler symmetries of the grids.

Looking at the relationship between the physical and the structural grid it turns out that at the ground floor the symmetrical and tripartite organisation of the structural grid at length is contrasted with the asymmetrical and non tripartite organisation of the physical grid, (TLH4 4.2, fig. 2, 3, p. 289, TLH4 4.3, fig. 1, 2, p. 290).

There is not a consistent pattern of relation between the structural and the physical grid at the first floor. Thus, whereas at the last stage there is no coincidence between the properties of the two grids, (TLH4 4.2, fig. 6, p. 289, TLH4 4.3, fig. 4, p. 290), at the second one the just about symmetrical and tripartite structure of the physical grid becomes a close approximation of the symmetrical and tripartite structure of the structural one, (TLH4 4.2, fig. 5, p. 289, TLH4 4.3, fig. 3, p. 290). Similarly to the ground floor the regular organisation of the structural grid at width is contrasted by the irregular organisation of the physical grid.

At the second floor a coincidence is constructed between the symmetrical organisation of the structural grid at length and the 'just about' symmetrical organisation of the physical grid, (TLH4 4.2, fig. 8, 9, p. 289, TLH4 4.3, fig. 5, 6, p. 290). At width there is no coincidence between the equal spacing of the structural grid bays and the irregular spacing of the physical grid bays.

Finally at the third floor the properties of the physical and the structural grid at length coincide, (TLH4 4.2, fig. 11, 12, p. 289, TLH4 4.3, fig. 7, 8, p. 290). At width the regular intervals of the structural grid are contrasted by the irregular ones of the physical grid.

The I/O line index at the ground floor moves from 0.21 to 0.15, (TLH4 4.5, p. 532). At the first and second floor it goes from 0.60 and 0.17 to 0.50 and 0.15 respectively. Finally, at third floor this index moves from 0.10 to 0.30. These low values indicate that there is very little coincidence between the lines defining the external articulation and those defining the internal one. Thus, similarly to the LH1, LH2 and LH3 there are no rules applied from the exterior to the interior in terms of the placement of the internal elements.

However, although there is no great deal of coincidence between the elements of the external and those of the internal organisation, at the second and third floor the grid of the internal elements seems to be physically defined. This is because the elements defining the superimposed components are aligned along the long direction of the plan. Thus, these are exceptional cases in which the grid becomes detectable due to an extensive linearisation of the elements of the interior.

To summarise, analysis of this house shows that a dissociation between the shape and the grid properties is constructed at the first, second floor and third floor at stage two and the second and third floor at stage three. In these cases the lack of overall symmetry is counterbalanced by the hidden symmetries of the grid lines.

Besides, analysis shows that there is no systematic pattern of relationship between the properties of one stage and the properties of the previous stage. Thus, the grid in process moves from symmetry to asymmetry and vice versa. Thus, there is no systematic application of rules from the exterior to the interior and from the largest to the smallest components.

Further, there is no systematic pattern of relationship between the structural and the physical grid. In certain cases the properties of the two grids coincide, while in others they contrast each other based on a distinction between the symmetrical and regular organisation of the former and the asymmetrical and organisation of the latter.

Finally, the lack of coincidence between the lines defining the internal and those defining the external organisation indicate that the geometrical grids are not physically defined by a systematic gathering of physical elements along their lines. In other words, the house does not reveal easily the logic of its geometry allowing the complicated patterns of the physical elements to camouflage it.

# APPENDIX 3

## Chapter 6 - S P A T I A L  A N A L Y S I S

### HOUSE AT PREGASSONA - ( B H 2 )

- **DESCRIPTION OF STAGES**

- **STAGE ONE**

At stage one there is a single Global Scale convex space covering the ground floor as a whole, (TB 5.1, fig. 10, p. 338). There is also Global Scale convex space extending at width that coincides with the central geometrical bay in all floors, (TB 5.1, fig. 10, 13, 16, p. 338). At the first and the second floor there are also two Global Scale convex spaces extending at width on either side of this bay, (TB 5.1, fig.13, 16, p. 338). At length there is a narrow Global Scale convex space situated at the front and a wider one at the back of the first floor. At the second floor there are two Global Scale convex spaces located at the back of the composition.

The organisation of the Global Scale convex spaces at width is symmetrical on the BF axis in all floors, (Symmetry Global Scale convex space index: 1, TB 5.9, p. 349). There is no symmetrical organisation of these spaces at length.

At the ground and first floor every spatial unit is a Global Scale unit, (TB 5.2, fig. 10, 13, p. 340). Besides, at the second floor a large number of spatial units are Global Scale units, (Global Scale-Unit index: 0.76, TB 5.2, fig. 16, p. 340, TB 5.10, p. 349). These are symmetrically distributed with respect to the BF axis, (Symmetry Global Scale-Unit index: 1, TB 5.11, p. 349).

The overlap units spread over the whole area of the first and second floor apart from the back left and right corners of the second floor, (TB 5.4, fig. 13, 16, p. 342). They are densely located sharing one or more neighbouring sides. All spatial units are symmetrically distributed on the BF axis in terms of shape, size, and overlap value, (Symmetry Spatial-unit index: 1, TB 5.12, p. 350).

The short path consists of units that are situated on the BF axis and on either side of this axis, (TB 5.5, fig. 10, 13, 16, p. 343). They are located next to each other sharing their defining sides. Their arrangement is also symmetrical with respect to this axis in terms of shape, size and position, (Symmetry Short Path-Unit index:1, TB 5.13, p. 350).

The most connected unit at the ground floor and first floor is situated on the BF axis, (TB 5.6, fig. 13, 16, p. 344, Invariance Value index: 1, TB 5.14, p. 350). At the second floor the most connected units are the rectangular unit located on the BF axis and two groups consisting of two units each that are symmetrical on this axis, (TB 5.6 fig. 16, p. 344, Invariance Value index: 0.65, TB 5.14, p. 350). The invariance values of the rest of the units are also symmetrical with respect to this axis in all floors, (Symmetry Invariance Value index: 1, TB 5.15, p. 351).

- **STAGE TWO**

The changes occurring at stage two as established in chapter four concern with the extension of the surfaces of the drum towards the interior in all floors, (TBH2 4.1, fig. 2, 5, 8, p. 255, see figures of Plan Analysis). They also concern with the superimposition of a planar L at the back left corner of the first floor and the superimposition of two rectangles at the back left and right corners and of two trapezoidal shapes at the front left and right corners of the second floor.

At this stage the ground floor is covered by three Global Scale convex spaces extending at width each of which coincides with a geometrical bay, (TB 5.1, fig. 11, p. 338). These spaces are symmetrically organised with respect to the BF axis. At the first floor the Global Scale convex space coinciding with the central geometrical bay at width and the geometrical bay on the right side of this space are retained, (TB 5.1, fig. 14, p. 338). There is no overall symmetry governing the disposition of these spaces at this stage, (Symmetry Global Scale convex Space index: 0.50, TB 5.9, p. 349). There are no changes introduced to the configuration of the Global Scale convex spaces at width at the second floor, (TB 5.1, fig. 17, p. 338).

At length there is one narrow Global Scale convex space at the front side of the ground and first floor as well as a narrow one situated off centre at the ground and second floor, (TB 5.1, fig. 11, 14, 17, p. 338). There is no symmetry characterising the organisation of the Global Scale convex spaces at length in any floor.

The ground floor is completely covered by Global Scale units, (TB 5.2, fig. 11, p. 340). At the first floor and the second floor the Global Scale-Unit index is 0.40 and 0.73 respectively, (TB 5.10, p. 349). Therefore, the majority of the units at the ground and second floor offer views that reach throughout the plan.

At the ground and second floor the organisation of the Global Scale units is governed by overall symmetry on the BF axis, (Symmetry Global Scale-Unit index: 1, TB 5.11, p. 349). At the first floor the organisation of these units is characterised by 'just about' symmetry, (Symmetry Global Scale-Unit index is 0.83).

The overlap units are arranged next to each other sharing one or more neighbouring sides, (TB 5.4, fig. 11, 14, 17, p. 342). At the first and second floor they cover the entire area of the plan apart from a part of the back left corner at the first floor and a part of the back left and right corners at the second floor. The Symmetry Spatial-Unit index at the ground floor is 1, while at the first and the second floor 0.20 and

0.73 respectively, (TB 5.12, p. 350). Therefore, there is overall symmetry, local symmetry and 'just about' symmetry governing the disposition of the spatial units.

The short path at the ground consists of units that are symmetrically organised on the BF axis, (TB 5.5, fig. 11, p. 343). At the second floor it is only the short path unit at the back right side of the plan that does not have an equivalent unit on the other side of the axis, (TB 5.5, fig. 17, p. 343). At first floor it is only a single short path unit that is covered by the BF axis. The rest of the units are not symmetrical on this axis, (TB 5.5, fig. 14, p. 343). The Symmetry Short Path-Unit index at the first and second floor is 0.25 and 0.83 respectively, (TB 5.13, p. 350). Therefore, there is local symmetry and 'just about' symmetry characterising the organisation of these units at these floors.

The most connected units at the ground floor are the two rectangular units situated on the BF axis, (TB 5.6, fig. 11, p. 344). At the first floor the most connected unit is also found on the BF axis, (TB 5.6, fig. 14, p. 344). Finally, at the second floor there are two groups consisting of three units each that are symmetrical on this axis, (TB 5.6, fig. 17, p. 344). The Invariance Value index of the most connected units at the ground floor is: 0.53. At the first and second floor this value is: 0.57 and 0.66 respectively, TB 5.14, p. 350).

The Symmetry Invariance-value index at the ground floor is 1, (TB 5.15, p. 351). At the first and second floor this index is 0.36 and 0.86 respectively. Therefore, there is overall symmetry, local symmetry and 'just about' symmetry characterising the disposition of the invariancevalues on these plans.

- **STAGE THREE**

At this stage two rectangles are superimposed at the back left and right corners of the ground floor, (TBH2 4.1, fig. 3, see figures of Plan Analysis, p. 255). At the first floor a rectangle is superimposed at the right side of the staircase drum, (TBH2 4.1, fig. 6, p. 255). There are no changes occurring at the second floor which remains as it is described at stage two.

The central Global Scale convex space extending at width is retained at both ground and first floor, (TB 5.1, fig. 12, 15, p. 338). At the first floor there is also a narrow GS c-space extending at width next to the right surface of the plan. At length the Global Scale convex spaces defined at the previous stages are retained. The only change occurring at this stage concerns the introduction of a narrow Global Scale convex space at the ground floor.

The Global Scale-Unit index at the ground floor is 0.68, (TB 5.10, p. 349). At the first floor this index is 0.52. Thus, over 50 percent of the spatial units in both floors offer information that reaches the outer limits of the layout. The Global Scale units at the ground floor are symmetrically distributed with respect to the BF axis, (Symmetry Global Scale-Unit index: 1, TB 5.11, p. 349). The Symmetry Global Scale-

Unit index at the first floor is 0.25. Thus, there is local symmetry organising the distribution of these units at this floor.

The overlap units at the ground floor occupy the central Global Scale convex space at width and the three Global Scale convex spaces extending at length, (TB 5.4, fig. 12, p. 342). At the first floor the overlap units cover the layout as a whole apart from a part of the enclosed spaces at the back left and right corner of the layout, (TB 5.4, fig. 15, p. 342). The Symmetry Spatial-Unit index at the ground floor is 1, (TB 5.12, p. 350). Therefore, there is overall symmetry governing the spatial units at the ground floor in terms of shape, size position and overlap value. There is a weaker pattern of symmetry at the first floor organising only 14 percent of these units, (TB 5.12, p. 350).

The short path units at the ground floor are symmetrical on the BF axis in terms of shape, size and position, (TB 5.5, fig. 12, p. 343). They are situated next to each other stretching from the left to the right side at the back of the plan. At the first floor there is only one short path unit on the BF axis. The rest occupy different locations requiring movement that stretches from left to right and from back to front, (TB 5.5, fig. 15, p. 343). The symmetry Short Path-Unit index at this floor is: 0.20, TB 5.13, p. 350).

The most connected units at the ground floor remain as defined at stage two with the exception of a new unit added on the BF axis, (TB 5.6, fig. 12, p. 344). At the first floor the most connected unit lies at the front right corner of the plan, (TB 5.6, fig. 15, p. 344). The Invariance Value index of the most connected units at these floors is: 0.50 and 0.52, (TB 5.14, p. 350).

The Symmetry Invariance Value index at the ground floor is 1. At the first floor this index is 0.28, (TB 5.15, p. 351). Therefore, it is only at the former that the distribution of the invariance values exhibits symmetry on the BF axis.

- **COMPARISON ACROSS STAGES**

- **Spatial properties**

At stage one the whole area of the ground and first floor and a large part of the second floor are covered by Global Scale convex spaces and Global Scale units (TB 5.1, fig. 10, 13, 16, TB 5.2, fig. 10, 13, 16, p. 338). Therefore, these layouts constantly offer views that reach the periphery of the plan in one or in both directions.

The ground floor is visible as a whole from the central short path unit, (TB 5.5 fig. 10, p. 343, TB 5.7, fig. 10, p. 347). At the first and second floor this unit shares its defining sides with the other short path units, (TB 5.5, fig. 13, 16, p. 343). The visual information provided from these sides is the sum of visual information provided from all units. In this way, an observer can see the layout as a whole moving from one side of this unit to the other[31], (TB 5.7, fig. 13, 16, p. 347).

In the following stages the central Global Scale convex space at width is preserved in all floors, (TB 5.1, fig. 11, 12, 14, 15, 17, p. 338). The two Global Scale convex spaces on either side of the central Global Scale convex space at the second floor are also preserved, (TB 5.1, fig. 17, p. 338). Finally, the Global Scale convex spaces extending at length at the front of the ground and first floor and the Global Scale convex space situated off centre at the ground and second floor are also retained, (TB 5.1, fig. 11, 12, 17, p. 338). The preservation of Global Scale convex spaces results in the preservation of the Global Scale units produced by their intersections, (TB 5.2, fig. 10-17, p. 340). Therefore, certain patterns of global scale information and the positions from which this is transmitted are retained.

Besides, the Global Scale-Unit index stays over 0.52 throughout the stages, (TB 5.10, p. 349). Thus, every stage preserves a large number of spatial units that provide visual information that extends at length or at width or in both directions .

In each stage a certain number of overlap units remain as defined in the previous stage in terms of shape, size, position and overlap value, (TB 5.4, fig. 10-17, p. 342). The side by side distribution of these throughout a large area of the plans stays also the same. In this way, simultaneous information about more than a single convex space is constantly offered throughout the stages.

Similarly to the overlap units certain short path units are also preserved in terms of shape, size and position, (TB 5.5, fig. 11, 12, 14, 15, 17, p. 343). Thus, the exposure of the ground and second floor from the central unit and its periphery is retained, (TB 5.7, fig. 10, 11, 12, 16, 17, p. 347). To receive a complete picture of the first floor one has to cover it as a whole moving from the centre to its sides, (TB 5.5, fig. 14, 15, p. 343). Nevertheless, a large area of the plan is visible from the central short path unit, (TB 5.7, fig. 14, 15, p. 347).

Finally, there are very few changes characterising the shape, size and position of most connected units in the ground and second floor plan. The Invariance Value index in all plans remains over 0.50 in every stage, (TB 5.14, p. 350). Therefore, a large degree of visual synchronisation is offered throughout the stages from the same units. Besides, a large number of visual fields that have constant contact with these units is provided throughout the stages.

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31 According to the definition of overlap from an o-unit two or more convex spaces are seen. Consequently, from the common line defining two o-units four or more convex spaces are visible. Thus, to see the first floor as a whole one needs to position himself on the defining line of the central unit. Thus, the above mentioned visual fields are drawn according to what is constantly seen from every spatial point as well as from the spatial points of the left and right defining sides of the central short path unit.

Thus, the transformation of spatial articulation retains certain patterns invariant. This seems to suggest that the organisation of space is constantly directed towards visual information that is rich both at the global and the local scale, short observation routes and constant visual contact with certain areas of the plans over a number of steps.

- **Physical properties of spatial articulation**

At stage one the outer surfaces in all floors are immediately visible from the central unit (TB 5.7, fig. 10, 13, 16, p. 347). From stage one to stage three the Global Scale convex spaces at the front of the ground and first floor and at the right of the first floor preserve the physical continuity of the outer surfaces extending at these positions, (TB 5.1, fig. 11, 12, 14, 15, p. 338). Besides, the preservation of the Global Scale unit on the BF axis at the ground and second floor preserves a simultaneous exposure of all surfaces of the layout from a single spatial location, (TB 5.7, fig. 11, 12, 17, p. 347).

To see all surfaces at the first floor one has to move more extensively, (TB 5.5, fig. 14, 15, p. 343). However, the surfaces of the void and the curvilinear elements at the back are simultaneously seen from the unit situated on the BF axis.

The dense network of overlap units at stage two gradually exposes the interrelationships of the surfaces in all floors, (TB 5.4, fig. 11, 12, 14, 15, 17, p. 342). The few changes introduced to this network at stage three preserve the successive synchronisation of surfaces as well as the positions from which this is offered.

The comparative examination of stages shows that in each stage spatial transformation preserves the physical coherence of certain outer surfaces. It also retains a simultaneous synchronisation of surfaces at the ground and second floor and a successive synchronisation of surfaces in all floors.

- **Geometrical properties of spatial articulation**

Analysis showed that at the ground and second floor the geometrical organisation of the Global Scale convex spaces, (TB 5.1, fig. 10-12, 16, 17, p. 338), the Global Scale units, (TB 5.2, fig. 10-12, 16, 17, p. 340), the spatial units, the short path units, (TB 5.5, fig. 10-12, 16, 17, p. 343), the most connected units, (TB 5.6, fig. 10-12, 16, 17, p. 344) and the invariance Values, (TB 5.15, p. 351), is governed by overall symmetry or 'just about' symmetry on the BF axis in all stages.

The organisation of these systems at the first floor moves from overall symmetry at stage one to local symmetry at stage three, (Symmetry Global Scale convex space index: 0.50, Symmetry Global Scale-Unit index 0.25, Symmetry Spatial-Unit index: 0.14, Symmetry Invariance Value index: 0.28). These figures show that apart from the Global Scale convex spaces the organisation of the rest of the systems is governed by weak patterns of symmetry.

Thus, the comparative examination of stages shows that the geometrical properties of each stage at the ground and second floor are subjected to the properties of the first stage. It turns out that visual information in these layouts is geometrically determined. There are global and local scale views offered from symmetrical Global Scale convex spaces and Global Scale units. There are also symmetrical visual fields constructed from symmetrical units, (TB 5.8, fig. 13-16, 15-16, 21-24, 23-24, p. 348). Finally, there is an exposure of the layouts as wholes from units that occupy geometrically significant locations and an invariant presence of geometrically significant locations in the majority of visual fields.

At the first floor there is less geometrical co-ordination of spatial information. Thus, spatial experience at this floor is less geometrically determined. However, this layout is experienced as a part of a more general system. This is the house as a whole in its internal and external spatial articulation and appearance. Seeing the symmetrical organisation of the house from the outside and the symmetrical organisation of the ground floor from the inside the visitor arrives at the first floor having already experienced a geometrical schema. In the previous chapter it was suggested that deviations from this schema tend to attract a keener attention. Thus, they seem to reinforce the symmetrical organisation governing the rest of the floors and the volume as a whole.

- **HOUSE AT MASSAGNO- (BH3)**

- **DESCRIPTION OF STAGES**

- **STAGE ONE**

At stage one there is a Global Scale convex space extending at width that coincides with the central geometrical bay in all floor plans, (TB 5.1, fig. 19, 22, 25, p. 338). At the first and second floor plans there is a wide and a narrow Global Scale convex space situated on either side of the central one, (TB 5.1, fig. 22, 25, p. 338, see also tables presenting convex spaces analytically, TBH3 5.1, fig. 10, 12, 17, 19, p. 359). A Global Scale convex space extending at length at the back of the composition is defined in all floors. At the first and second floor there is also a Global Scale convex space extending at the front of the plan.

The organisation of these spaces at the first and the second floor is governed by overall symmetry on the BF and the LR axis, (Symmetry Global Scale convex space index: 1, TB 5.9, p. 349). At the ground floor there is only local symmetry governing the disposition of the Global Scale convex spaces, (Symmetry Global Scale convex space index: 0.50).

The first and second floors are completely covered by Global Scale units (GS-unit index: 1, TB 5.2, fig. 22, 25, p. 340). These are placed next to each other sharing one or more defining sides. The Global

Scale-Unit index at the ground floor is 0.50. Thus, in the former every spatial unit provides information that reaches the outer limits of the plan. In the latter there are fewer unit that do so.

The Symmetry Global Scale-Unit index at the ground floor is 0.84, (TB 5.11, p. 349). At the first and the second floor this index is 0.68 and 0.88 respectively. Therefore, the geometrical organisation of the Global Scale units is governed by 'just about' symmetry with respect to the BF axis in all floors.

The Symmetry spatial-Unit index at the ground floor is 0.88, (TB 5.12, p. 350). At the first and second floor this index is 0.78 and 0. 87 respectively. Therefore, the organisation of the spatial units is also characterised by 'just about' symmetry in terms of shape, position and overlap value in all floors.

The short path units at the ground floor are situated at the back and the front of the BF axis, on either side of this axis as well as at the back left and right corners of the plan, (TB 5.5, fig. 19, p. 343). At the first and the second floor there is one unit at the back of the axis and one unit on its either side, (TB 5.5, fig. 22, 25, p. 343). The visual fields constructed from this unit and its periphery reveal the layouts as wholes, (TB 5.7, fig. 22, 25, p. 347). The organisation of the short path map is symmetrical on the BF axis in all floors.

The most connected unit at the ground floor is situated at the back right corner of the plan, (TB 5.6, fig. 19, p. 344). At the first floor the most connected unit is the rectangular unit at the right side of the BF axis, (TB 5.6, fig. 22, p. 344). At the second floor the most connected units are situated on either side of the BF axis at the front of the composition, (TB 5.6, fig. 25, p. 344). The Invariance Value index of the most connected units at the ground floor is: 0.42, (TB 5.14, p. 350). At the first and second floor this value is 0.73, and 0.71 respectively[32].

The Symmetry Invariance Value index at the ground floor is 0.73, (TB 5.15, p. 351). At the first and second floor this index is 0.40 and 0.87 respectively. Therefore, there is 'just about' symmetry and local symmetry characterising the distribution of the invariance values of the rest of the units in these floors.

- **STAGE TWO**

At stage two the transformations occurring at the ground floor concern with the superimposition of two shapes on either side of the vertical shaft at the ground floor, (TBH3 4.1, fig. 2, p. 256, see figures of Plan Analysis). At the first floor there are two small rectangles superimposed at the back of the first

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32 At the second floor the most connected units are only 'seen' without 'seeing' other units. This is because they are located inside the void. The most connected units that can 'see' and be 'seen' from other units are the rectangular units on either side of the axis and the triangular and trapezoidal units at the front left and right corners of the plan, Invariance-Value index: 14/16=0.87, (TB 5.14, p. 350).

floor, (TBH3 4.1, fig. 5, p. 256). Finally, at the third floor there is a shape superimposed at the front right side of the plan and a free standing element added on the front left side, (TBH3 4.1, fig. 8, p. 256).

At this stage the Global Scale convex space coinciding with the central geometrical bay is retained in all plans, (TB 5.1, fig. 19-27, p. 338). At the first and second floor there are four Global Scale convex spaces extending at width each of which coincides with a geometrical bay. The Global Scale convex space extending at length at the front of the composition is also retained at both first and second floor. Finally, at the ground and first floor there is a Global Scale convex space extending at length at the back of the plan.

The Symmetry Global Scale convex space index at the ground and first floor is 1, (TB 5.9, p. 349). At the second floor this index is 0.60. Thus, there is overall symmetry and local symmetry characterising the distribution of the Global Scale convex spaces.

The Global Scale-Unit index at the ground floor is 0.38, (TB 5.10, p. 349). At the first and the second floor plans this index is 0.76 and 0.58 respectively. Thus, at the first and second floor there is a large number of spatial units offering large scale information. On the other hand, at the ground floor there are fewer positions providing visual fields that reach the outer limits of the plan.

The Symmetry Global Scale-Unit index at the ground floor is 1, (TB 5.11, p. 349). At the first and second floor this index is 0.76 and 0.64 respectively. Therefore, the organisation of these units is governed by overall symmetry, 'just about' symmetry and local symmetry on the BF axis.

The overlap units at the ground floor cover the central part of the plan extending from back to front and from left to right of the composition, (TB 5.4, fig. 20, p. 342). At the first floor they cover the entire area of the layout apart from the enclosed spaces at the back of the plan, (TB 5.4, fig. 23, p. 342). Their arrangement creates a chequerboard pattern with rhythmical alternations of overlap values in both directions that follow the rhythmical spacing of the geometrical bays. At the second floor these units spread throughout the plan apart from the areas on either side of the drum and a part of the enclosed space at the back right corner, (TB 5.4, fig. 26, p. 342).

In all these plans the overlap units are arranged next to each other sharing their defining lines. The only exceptions are the units situated inside the enclosed spaces at the front left and right corner of the ground floor which are isolated from the others.

The Symmetry Spatial-Unit index at the ground floor is 0.90, (TB 5.12, p. 350). At the first and second floor this index is 0.87 and 0.37 respectively. Therefore, there is 'just about' symmetry and local symmetry characterising the organisation of the spatial units in terms of shape, position and overlap value.

The short path at the ground floor consists of units situated on the BF axis as well as on either side of the axis, (TB 5.5, fig. 20, p. 343). At the first floor the short path units spread from left to right at the back of the plan, (TB 5.5, fig. 23, p. 343). At the second floor the short path consists of a cluster of units gathered around the BF axis, a triangular unit on the left side of the void and a rectangular unit at the right central side of the plan, (TB 5.5, fig. 26, p. 342).

The Symmetry Short Path-Unit index at the ground floor is: 0.66, (TB 5.13, p. 350). At the first and the second floor this index is 1 and 0.50 respectively. Therefore, the distribution of these units at the ground floor is characterised by overall symmetry. In the rest of the floors there is local symmetry organisng the short path units.

The most connected unit at the ground floor is the curvilinear unit situated on the BF axis, (TB 5.6, fig. 20, p. 344). At the first floor these are the two units at the right side of the plan, (TB 5.6, fig. 23, p. 344). Finally, at the second floor the most connected units are situated on the left side of the BF axis and the front left corner of the composition, (TB 5.6, fig. 26, p. 344). The Invariance Value index of the most connected unit at the ground floor is : 0.48, (TB 5.14, p. 350). At the first and second floor this value is 0.55 and 0.80 respectively, TB 5.14, p. 350).

The Symmetry Invariance-Value index at the ground floor is 0.45, (TB 5.15, p. 351). At the first and second floor this index is 0.27 and 0.30. There is local symmetry characterising the distribution of the invariance values in all floors.

- **STAGE THREE**

At stage three the changes occurring at the ground floor are about the superimposition of two shapes at the back left and right corners of the ground and second floor and the addition of a a partition at the left side of the second floor, (TBH3 4.1, fig. 6, 9, p. 256, see figures of Plan Analysis). There are no changes introduced to the first floor plan.

At this stage the central Global Scale convex space extending at width and the Global Scale convex space extending at length at the front of the composition is retained at both ground and second floor, (TB 5.1, fig. 21, 27, p. 338). At the second floor the Global Scale convex spaces extending at width on either side of the central one and the Global Scale convex space extending at the left side of the plan are also preserved. Finally, a narrow Global Scale convex space is defined extending at the right side of this plan. The organisation of these spaces is governed by overall symmetry and tripartition with respect to the BF axis and the central geometrical bay in both floors, (Symmetry Global Scale convex space index: 1, TB 5.9, 349).

The Global Scale-Unit index at the ground floor is 0.11, (TB 5.10, p. 349). At the second floor this index is 0.48. Therefore, it is only the second floor that constructs visual fields that reach throughout the plan. The Symmetry Global Scale-Unit index at the ground floor is 1, (TB 5.11, p. 349). At the second floor this index is 0.48. Thus, there is overall symmetry and local symmetry characterising the distribution of the Global Scale units.

The overlap units at the ground floor are mainly located at the central and the front side of the composition, (TB 5.4, fig. 21, p. 342). At the second floor these units cover the front left side, the right central and back side of the plan as well as the area in front of the drum, (TB 5.4, fig. 27, p. 342). At these stage the overlap units are formed into clusters separated by intervening surfaces. However, the units belonging to each cluster share their defining lines in both floors.

The Symmetry spatial-Unit index at the ground floor is 0.38, (TB 5.12, p. 350). At the second floor this index is 0.43. Therefore, there is only local symmetry characterising the distribution of the spatial units at this stage.

The short path at the ground floor consists of units clustering around the BF axis and of a number of units located inside the enclosed spaces at the back and front left corner of the plan, (TB 5.5, fig. 21, p. 343). At the second floor the short path units are situated on the BF axis, on either side of this axis, next to the left and right surfaces and inside the enclosed spaces at the back left and right corners of the plan, (TB 5.5, fig. 27, p. 343). The symmetry Short Path-Unit index at the ground floor is 0.44, (TB 5.13, p. 350). At the seond floor it is 0.33. Therefore, there is local symmetry characterising the distribution of the short path units on these plans.

The most connected units at the ground floor is the curvilinear unit and the rectangular unit situated on the BF axis, (TB 5.6, fig. 21, p. 344). At the second floor the most connected units are situated at the front right side of the central Global Scale convex space and at the front right corner of the plan[33], (TB 5.6, fig. 27, p. 344). The Invariance Value index of the most connected units at the ground floor is 0.45, (TB 5.14, p. 350). At the second floor this index is: 0.58.

The Symmetry Invariance Value index at the ground floor is 0.27 At the second floor this index is 0.17. Therefore, the distribution of the invariance values at the ground floor is governed by local symmetry. At the second floor the pattern of symmetry is rather weak because only 17 percent of these values are symmetrical on the BF axis.

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33 These units are only 'seen' by other units. The most connected units that 'see' and are 'seen' are situated inside the enclosed space at the front right corner, Invariance-Value index: 0.48, (TB 5.14, p. 350).

- **COMPARISON ACROSS STAGES**

- **Spatial properties**

At stage one every single point at the first and the second floor belongs to a Global Scale convex space and to a Global Scale unit, (TB 5.1, fig. 19, 22, 25, TB 5.2, fig. 19, 22, 25, p. 338). Therefore, there is constant visual information that reaches the outer limits of the plans in one or in two directions. Besides, the layouts are seen as wholes from the periphery of the central short path unit (TB, 5.7, fig. 22, 25, p. 347).

At the ground floor there are fewer locations providing visual fields that reach throughout the layout, (Global Scale-Unit index: 0.50, TB 5.10, p. 349). However, although this layout requires an observation route that extends from the back to the front and from the back left to the back right side, (TB 5.5, fig. 19, p. 343), a large portion of the layout is revealed from the central short path unit.

From stage one to stage three there are no changes to the central Global Scale convex space in all floors, (TB 5.1 fig.19-27, p. 338). There are no changes to the Global Scale convex spaces on either side of the central geometrical bay at the second floor either, (TB 5.1, fig. 26, 27, p. 338). Besides, the GlobAl Scale convex space extending at length at the front of the first and the second floor remains the same in all stages, (TB 5.1, fig. 22, 23, 25-27, p. 338). The Global Scale units defined by the intersections of these Global Scale convex spaces stay also the same, (TB 5.2, fig. 19-27, p. 340). Therefore, certain spatial patterns controlling the transmission of global scale views are embedded into the properties of the first stage.

The Global Scale-unit index remains over 0.48 in both first and second floor in every stage, (TB 5.10, p. 349). Thus, spatial transformation preserves a large number of visual fields that offer global scale visual information.

In both stages two and three there is a continuous distribution of overlap units, (TB 5.4, fig. 21, 23, 27, p. 342). There is also a complete coverage of the first and second floor by these elements. This shows that there is a constant synchronisation of convex spaces in all stages.

The configuration of the short path map changes to include an increased number of units in all floors, (TB 5.5, fig. 20, 21, 23, 26, 27, p. 343). However, the first floor is seen almost as a whole from the central short path unit, (TB 5.7, fig. 23, p. 347). Besides, the short path units gathered around the BF axis at the ground and second floor remain the same in terms of shape, size and position, (TB 5.5, fig. 21, 27, p. 343). Thus, the central part of these layouts is revealed through the same small scale route in all stages. To see the rest of the plan, though, movement is required that covers the interiors as wholes from the left to the right side.

The most connected units at the ground floor retain the position on the BF axis from stage two to stage three, (TB 5.6, fig. 19-21, p. 344). In the rest of the floors the shape, size and position of the most connected units changes, (TB 5.6, fig. 22-27, p. 344). In this respect, the position offering visual synchronisation and staying invariant in a number of visual fields at the ground floor is preserved. On the other hand, the positions that have these properties in the rest of the floors are altered.

However, the Invariance Value index stays over 0.45 throughout the stages in every floor, (TB 5.14, p. 350). Therefore, there seems to be a consistent tendency to preserve a large degree of visual synchronisation and a large number of visual fields that retain constant contact with the most connected units.

To summarise, the analysis of spatial properties shows that in each stage certain spatial properties are subjected to the properties of the previous stage. These properties result in a large degree of global scale visual information, in a synchronisation of global and local scale relations from a single unit or form a number of units and in a spatial information that remains constant as one changes his position in space.

At the ground floor transformation frees itself from the limitations of stage one. Thus, there is less synchronisation of global and local scale elements. There is also a spatial exploration that spreads in many different locations. The second floor is also seen through many and separate positions. However, visual fields in this floor successively synchronise global and local scale spatial relations. Besides, a large number of these fields retain contact with the most connected units.

- **Physical properties of spatial articulation**

At stage one the outer surfaces at the first and second floor are visible as wholes from the Global Scale convex spaces extending next to them, (TB 5.1, fig. 22, 25, p. 338). Besides, every surface in these layouts is directly observed from the central short path unit, (TB 5.7, fig. 22, 25, p. 347).

At the ground floor there is no short path unit revealing the physical system at once, (TB 5.5, fig. 19, p. 343). However, from the central short path unit a large part of the layout is revealed, (TB 5.7, fig. 19, p. 347). Besides, there are global scale views constructed from the Global Scale convex spaces and the Global Scale units, (TB 5.1, fig. 19, p. 338, TB 5.2, fig. 19, p. 340). There is also a gradual synchronisation of surfaces constructed from the continuous network of Global Scale units and overlap units in all floors, (TB 5.2, fig. 19, 22, 25, p. 340, TB 5.4, fig. 19, 22, 25, p. 342). These views successively expose the surfaces of the block, the void and the curvilinear surface at the back of the plan.

From stage one to stage three the Global Scale convex spaces extending next to the left, the right and the front surfaces of the first and the second floor are preserved retaining also the physical continuity of these surfaces, (TB 5.1, fig. 22-27, p. 338). The patterns of relations amongst the Global Scale convex spaces are also preserved preserving a Global Scale unit at the front of the staircase shaft at the first floor, (TB

5.2, fig. 23, p. 340). From this unit almost every physical element is directly visible, (TB 5.7, fig. 23, p. 347).

At the second floor the outer surfaces are seen as wholes only through peripheral exploration, (TB 5.1, fig. 926, 27, p. 338). Thus, whereas at the first floor all surfaces are simultaneously seen soon after the beginning of the exploration route, at this layout they are gradually seen after observation is carried out in smaller detail. During this observation a gradual synchronisation of surfaces is constructed from the dense and continuous network of the Global Scale units and the overlap units.

At the ground floor the Global Scale convex spaces and the Global Scale units become increasingly fewer reducing the physical continuity of the outer surfaces and the amount of visual fields connecting the outer surfaces from distance, (TB 5.1, fig. 20, 21, TB 5.2, fig. 20, 21, p. 338). To build an image of the outer boundary one has to move extensively from the centre to the sides of the plan entering enclosed spaces that interrupt its continuity, (TB 5.5, fig. 20, 21, p. 343).

The overlap units become increasingly dispersed separated from each other by non overlapping units, (TB 5.4, fig. 20, 21, p. 342). Therefore, there are certain areas in the plan from which only the defining surfaces of a single convex space are visible. In this way, the interconnections amongst surfaces become less exposed.

To summarise, at the first floor there is an immediate synchronisation of all surfaces from a single place and a gradual synchronisation from a large number of places. At the second floor simultaneous information about the interconnections amongst surfaces is only gradually exposed. Finally, at the ground floor the interconnections become less accessible as information unwinds in a discontinuous way isolating boundaries from each other.

- **Geometrical properties of spatial articulation**

The organisation of the Global Scale convex spaces, (TB 5.1, fig. 19-27, p. 338), the Global Scale units, (TB 5.2, fig. 19-27, p. 340), the spatial units, (TB 5.12, p. 350), and the short path units, (TB 5.5, fig. 1-9, p. 343) is characterised by overall symmetry, 'just about' symmetry and local symmetry throughout the stages in all floors. Therefore, the geometrical properties in every stage either coincide or approximate the geometrical properties of the first stage.

This coincidence or close approximation results in global and local scale information offered from symmetrical positions. It also results in an exploration route that crosses symmetrical spatial units exposing also symmetrical or almost symmetrical portions of the layout, (TB 5.8, fig. 25-26, 29-30, 31-32, 35-36, p. 348). The geometrical co-ordination of visual information shows that geometry interferes in the experience of the building synchronising relations from distance.

However, certain deviations from symmetry take place. These are based on the placement of the most connected units in positions that are non geometrically co-ordinated, (TB 5.6, fig. 21, 23, 26, 27, p. 344). Thus, although symmetrical views are constructed from symmetrical positions visual synchronisation occurs from units that do not have equivalent units on the other side of the axis. The deviation from symmetry is also based on an overall symmetry in terms of one shape characteristic, (shape and position), and asymmetry in terms of another, (size). In the previous chapter it was suggested that such devices increase the viewer's attention to symmetry reinforcing the overall pattern.

- **HOUSE AT STABBIO - (BH4)**

- **DESCRIPTION OF STAGES**

- **STAGE ONE**

At stage one there are seven Global Scale convex spaces extending from back to front at the ground floor[34], (TB 5.1, fig. 28, p. 338, for an analytical presentation of these spaces see also TBH4 5.1, fig. 1, 3, 4, p. 362). There are also seven Global Scale convex spaces stretching from back to front at the first floor, (TB 5.1, fig. 31, p. 338, see also TBH4 5.1, fig. 10, 13, p. 362). Finally, at the second floor there are three Global Scale convex spaces extending along this direction, (TB 5.1, fig. 34, p. 338, see also TBH4 5.1, fig. 19, 24, p. 362).

There is one Global Scale convex space extending from left to right at the ground floor, (TB 5.1, fig. 28, p. 338). At the first floor there are two Global Scale convex spaces stretching on this direction, (TB 5.1, fig. 31, p. 338, see also TBH4 5.1, fig. 9, 15, p. 362). Finally, at the second floor there are three Global Scale convex spaces extending from the left to the right side of the plan, (TB 5.1, fig. 34, p. 338, see also TBH4 5.1, fig. 15, 22, p. 362).

The Symmetry Global Scale convex space index in both ground and first floor is 1, (TB 5.9, p. 349). At the second floor it is 0.33. Therefore, there is overall symmetry and local symmetry on the BF axis governing the distribution of these spaces.

Every single unit is a Global Scale unit in all floors, (TB 5.2, fig. 28, 31, 34, p. 340), (Global Scale-Unit index: 1, TB 5.10, p. 349). The Symmetry Global Scale-Unit Index at the ground and first floor is

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34 In a circular layout like the one examined here convex spaces are considered as Global Scale convex spaces when every point of their opposite sides reaches the outer surfaces of the volume. The convex spaces presented in TBH4 5.1, fig. 5, (p. 362), for example, are not considered as Global Scale convex spaces because their front sides are not defined by the external surface.

1, (TB 5.11, p. 340). At the second floor this index is 0.46. Therefore, there is overall and local symmetry governing the organisation of the Global Scale units.

The short paths consists of one unit situated on the BF axis and two, (first floor), or more units, (ground and second floor), that are symmetrical on this axis, (TB 5.5, fig. 28, 31, 34, p. 343). Therefore, overall symmetry on the BF axis characterises the short path units in all floors. Besides, the visual fields constructed from the central short path units expose the layouts as wholes in every floor, (BH 5.7, fig. 28, 31, 34, p. 347).

The most connected units at the ground floor are the two rectangular units on either side of the central one, (TB 5.6, fig. 28, p. 344). At the first floor there are two groups of most connected units consisting of four units each. These are located on either side of the central unit, (TB 5.6, fig. 31, p. 344). Finally, at the second floor these units are nine units covering the plan from back to front and from left to right, (TB 5.6, fig. 34). The Invariance Value index of the most connected units at the ground floor is: 0.70, (TB 5.14, p. 350). At the first and second floor this value is 0.80 and 0.92 respectively.

In all these floors the distribution of these units is characterised by overall symmetry on the BF axis. Besides, the Symmetry Invariance Value index at the ground and the first floor is 1, (TB 5.15, p. 351). At the second floor this index is 0.69. Therefore, the distribution of the invariance values of the rest of the units is governed by overall symmetry and local symmetry on this axis.

- **STAGE TWO**

At stage two the changes transforming the ground floor are about the superimposition of a shape stretching from back to front at the centre of the plan, (TBH4 4.1, fig. 2, p. 257, see figures of Plan Analysis). At the first and second floor the surfaces of the drum are extended towards the interior of the house, (TBH4 4.1, fig. 5, 8, p. 257, see figures of Plan Analysis). Besides, three shapes are superimposed at the left side and a void is added at the centre of the second floor.

At this stage there are seven Global Scale convex spaces extending from back to front at the ground and first floor, (TB 5.1, fig. 29, 32, p. 338, see also analytical presentation of convex spaces in TBH4, 5.2, fig. 1, 6, 9, 13, 14, p. 363). At the second floor there are two Global Scale convex spaces stretching along this direction, (TB 5.1, fig. 35, p. 338).

There is no Global Scale convex space extending from left to right at the ground floor, (TB 5.1, fig. 29, p. 338). At the first floor there are two Global Scale convex spaces extending along this direction, (TB 5.1, fig. 5, p. 338, TBH4 5.2, fig. 11, 16, p. 363). Finally, at the second floor there are two narrow GS c-spaces that are symmetrically arranged on the LR axis, (TB 5.1, fig. 35, p. 338).

The Symmetry Global Scale convex space index at the ground and first floor is 1, (TB 5.9, p. 349). This index at the second floor is 0.50. Thus, overall symmetry characterises the arrangement of the Global Scale convex spaces at the ground and first floor. On the other hand, there is local symmetry organising these spaces at the second floor.

The overlap units cover the entire area of the plans apart from parts of the enclosed spaces at the ground and second floor, (TB 5.4, fig. 29, 32, 35, p. 342). They are arranged next to each other sharing one or more defining lines. The Symmetry Spatial-Unit index at the ground and first floor is 1, (TB 5.12, p. 350). At the second floor this index is: 0.10. The distribution of the spatial units on the ground and first floor is, thus, governed by overall symmetry in terms of size, shape, position and overlap value. On the other hand, there are very few spatial units that are symmetrical on the BF axis at the second floor.

The ground and first floor are covered as wholes by Global Scale units, (TB 5.2, fig. 29, 32, p. 340). These are symmetrically distributed with respect to the BF axis in terms of shape, size and position in both floors, (Symmetry Global Scale-Unit index: 1, TB 5.11, p. 349). At the second floor this index is 0.33. Therefore, the distribution of these units at this floor exhibits local symmetry.

The short paths at the ground and first floor consist of a unit situated on the BF axis and two, (first floor), or more units, (ground floor), that are symmetrically distributed with respect to this axis, (TB 5.5, fig. 29, 32, p. 340). At the first floor these units are located next to each other sharing their defining lines. The visual field produced from the central short path unit in this floor exposes the layout as a whole, (TB, 5.7, fig. 32, p. 347).

At the second floor the short path consists of unit situated on the BF axis, a unit located on its right side, and three units each of which is situated inside one of the three enclosed spaces at the left side of the composition, (TB 5.5, fig. 35, p. 343). The Symmetry short Path-Unit index at this floor is: 0.20, (TB 5.13, p. 350).

The most connected units at the ground floor are the two groups of units each of which consists of three units that are situated at the left and right side of the plan, (TB 5.6, fig. 29, p. 344). At the first floor these are also two groups consisting of four units each situated at the front left and right side of the composition, (TB 5.6, fig. 32, p. 344). Finally, at the second floor the most connected units are the two rectilinear units at the right side of the plan, (TB 5.6, fig. 35, p. 344).

The Invariance Value index of the most connected units at the ground floor is 0.38, TB 5.14, p. 350). At the first and second floor this index is 0.73 and 0.55 respectively.

At both the ground and first floors these units are symmetrically distributed with respect to the BF axis. Besides, The Symmetry Invariance Value index at these floors is 1, (TB 5.15, p. 351). Therefore, the distribution of the rest of invariance values is governed by overall symmetry on the BF axis in both plans. On the other hand, at the second floor the most connected units are symmetrical on the LR axis. The Symmetry Invariance Value index is: 0.21 on the BF axis and 0.62 on the LR axis. Therefore, the distribution of the invariance values is based on local symmetry on these axes.

- **STAGE THREE**

At stage three there are two shapes superimposed at the left side of the ground floor, (TBH4 4.1, fig. 3, p. 257, see figures of Plan Analysis). There are also two shapes superimposed at the front side of the plan. At the first floor a rectilinear element is added at the right side of the composition, (TBH4 4.1, fig. 6, p. 257, see figures of Plan Analysis). Finally, at the second floor two such elements are added at the right side of the plan, (TBH4 4.1, fig. 9, p. 257, see figures of Plan Analysis).

The central Global Scale convex space extending from back to front is retained at both first and second floors, (TB 5.1, fig. 33, 36, p. 338). At the ground floor there are five Global Scale convex spaces extending from back to front, (TB 5.1, fig. 30, p. 338, see also analytical presentation of convex spaces in TBH4 5.3, fig. 1, 5, 7, p. 364). At the first floor there are also four Global Scale convex spaces extending along this direction, (TB 5.1, fig. 33, p. 338, see also TBH4 5.3, fig. 9, 13, p. 364). Finally, at the second floor there is Global Scale convex space at the right side of the plan, (TB 5.1, fig. 36, p. 338).

The configuration of the Global Scale convex spaces along the other direction at the ground and first floor remains as defined at stage two. At the second floor there is only a single Global Scale convex space extending from left to right of the composition, (TB 5.1, fig. 36, p. 338).

The Symmetry Glocal Scale convex space index at the ground floor is 0.80, (TB 5.9, p. 349). At the first and second floor this index is 0.25 and 0.50 respectively. Therefore there is 'just about' and local symmetry characterising the organisation of these spaces.

The overlap units cover a large area of the ground floor apart from parts of the enclosed elements at the centre, the left and the front side of the plan, (TB 5.4, fig. 30, p. 342). At the first floor they cover the entire layout apart from a small area at the right side, (TB 5.4, fig. 33, p. 342). At the second floor there are no major changes introduced to the overlap units, (TB 5.4, fig. 3, p. 342). These units are arranged next to each other sharing one or more defining sides in all floors[35].

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35 The only exceptions are the overlap units at the back right side of the first and the second floor which are disconnected from the rest of the units.

The Symmetry Spatial-Unit index at the ground floor is: 0.50, (TB 5.12, p. 350). At the first and the second floor this index is 0.58 and 0.34 respectively. Thus, there is local symmetry characterising the distribution of the spatial units in terms of shape, position and overlap value in all floors.

The Global Scale-Unit index at the ground floor is 0.67, (TB 5.10, p. 349). At the first floor this index is 0.83, while at the second floor 0.40. Thus, the Global Scale units cover a large area of the ground and first floor plans, (TB 5.2, fig. 30, 33, p. 340). The Symmetry Global Scale-Unit index at the ground floor is: 0.52, (TB 5.11). At the first and second floor this index is 0.86 and 0.58 respectively. Therefore, the Global Scale units are governed by 'just about' and local symmetry in all floors.

The short path units at the ground floor are mainly situated close to each other covering the front left and right side of the plan, (TB 5.5, fig. 30, p. 343). At the first floor the short path consists of a unit situated on the BF axis, a unit on its left side and a triangular unit at the back right side of the plan, (TB 5.5, fig. 33, p. 343). The central unit reveals a large part of the layout. Finally, at the second floor there are no major changes to the short path units apart from the introduction of two units at the back right side of the composition, (TB 5.5, fig. 36, p. 343).

The symmetry Short Path-Unit index at the ground floor is: 0.71, (TB 5.13, p. 350). At the first and second floor it is only the central unit that is symmetrical on this axis, (TB 5.5, fig. 33, p. 343, Symmetry Short Path-Unit: 0.33). At the second floor this index is 0.16. Therefore, there is 'just about' symmetry at the ground floor and local symmetry at the rest of the floors characterising the distribution of the short path units.

The most connected units at the ground floor are the triangular unit at the front left side and the triangular and rectangular units at the back left side of the plan, (TB 5.6, fig. 30, p. 344). At the first floor these are the four units occupying the left front left side of the composition, (TB 5.6, fig. 33, p. 344). Finally, at the second floor the most connected unit is the unit situated on the landing, (TB 5.6, fig. 36, p. 344). It is only at this floor that the most connected unit is symmetrical is symmetrically positioned with respect to the BF axis.

The Invariance Value index of the most connected units at the ground floor is: 0.35, TB 5.14, p. 350). At the first and second floor this index is 0.77 and 0.47 respectively. The Symmetry Invariance-Value index for the ground floor is: 0.07. This index at the first floor and second floor is 0.13 and 0.16. Thus, there are very few units that are symmetrically distributed in terms of invariance values in all floors.

## • COMPARISON ACROSS STAGES

### • Spatial properties

At stage one all floor plans are fully covered by Global Scale convex spaces, (TB 5.1, fig. 28, 31, 34, p. 338) and Global Scale units, (TB 5.2, fig. 28, 31, 34, p. 340). There is, thus, maximum visual information reaching the outer limits of the volumes from every single location. Besides, all floors are seen as wholes from the central short path unit, (TB 5.7, fig. 28, 31, 34, p. 347).

From stage one to stage three the central Global Scale convex space extending from the back to the front of the composition is preserved in both first and second floor, (TB 5.1, fig. 31-33, 34-36, p. 338). Certain Global Scale convex spaces extending at the same direction at the ground and second floor are also preserved, (see analytical presentation of convex spaces, TBH4 5.1, fig. 1, 3, 4, 10, 13, p. 362, TBH4 5.2, fig. 1, 6, 9, 13, 14, p. 363, TBH4 5.3, fig. 1, 5, 7, 9, 13, p. 364). Besides, from stage two to stage three particular Global Scale convex spaces stretching from left to right at the first and the second floor are also retained, (TB 5.1, fig. 29, 30, 35, 36, p. 338). The Global Scale units produced by the intersections of these GS c-spaces are consequently preserved, (TB 5.2, fig. 28-36, p. 340). Therefore, certain patterns of global spatial relations and the positions from which there are visible stay invariant along the analytic sequences.

The Global Scale-Unit index remains over 0.40 in all floor plans throughout the stages, (TB 5.10, p. 349). At the ground and the first floor transformation retains the side by side disposition of the Global Scale units and their distribution over a large area of the plans, (TB 5.2, fig. 28-36, p. 340) Thus, it retains a large degree of global scale visual information and a continuous pattern of its transmission[36].

Further, each stage preserves particular short path units as these are defined in the previous stage in terms of shape, size and position, (TB 5.5, fig. 28-36, p. 340). Similarly to stage one the visual fields produced from the central unit at the first floor expose either this layout as a whole, (stage two), or a large part of it, (stage three), (TB 5.7, fig. 32, 33, p. 347).

On the other hand, the exposure of the ground and second floor as wholes through a single short path unit occurring at stage one is not retained. At stage three these layouts are seen through a more extended exploration, (TB 5.5, fig. 29, 30, 35, 36, p. 343). However, although the observation route at the ground floor covers a number of different positions it develops through small scale movement that covers the front side of the plan. At the second floor the short path units spread at different positions requiring movement that extends from the left to the right and from the left back to the left front side of the plan.

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36 The majority of the overlap units at the ground and second floor are Global Scale units. Therefore, examination of the transformation patterns of the overlap units is not attempted as this is already covered by the examination of the Global Scale units.

The shape, size and position of the most connected units changes along the analytic stages, (TB 5.6, fig. 28-36, p. 344). Therefore, the positions form which visual synchronisation is offered as well as the areas that are constantly visible from a large number of visual fields do not stay the same. However, the Invariance-Value index of the most connected units remains over 0.35 in all floors throughout the stages, (TB 5.14, p. 350). Thus, there is an emphasis in retaining a certain degree of visual synchronisation and a degree of invariant visual information.

Thus, the comparison across stages shows that transformation retains certain spatial patterns invariant. This results in a preservation of certain characteristics of spatial experience as this is constructed at stage one. These are based on a constant provision of global scale views, on an exposure of the layout from a single position or from a short observation route, on visual synchronisation of spatial relations and visual fields that offer access to same part of the layout.

At the first floor these characteristics are stronger based on a more systematic preservation of properties. Thus, there is a high Global Scale-Unit index, (0.83, TB 5.10, p. 349), and Invariance Value index, (0.77, TB 5.14, p. 350), a large and continuous coverage by Global Scale units and an exposure from a single unit. Besides, the amount of visual information that features in most visual fields, i.e. the most connected units, covers a large part of the layout as opposed to the ground and second floor where the most connected units are small scale units covering a very small part of the plans. Thus, in this floor a large area is constantly visible from a large number of steps

- **Physical properties of spatial articulation**

At stage one the left and the right surfaces of the cylinder are visible from the large Global Scale convex space covering the layouts from left to right, (TB 5.1, fig. 28, 31, 34, p. 338). These surfaces together with every other surface in the layouts are immediately visible from the central short path unit, (TB 5.7, fig. 28, 31, 34, p. 347).

In the following stages the right surface of the cylinder at the ground and second floor and both the left and the right sides at the first floor are seen as physically continuous elements, (TB 5.1, fig. 29, 30, 32, 33, 35, 36, p. 338). Besides, The value of the Global Scale-Unit index stays high in all stages. Therefore, there are visual fields that synchronise the outer surfaces of the volume from distance in every stage.

At the first floor the cylindrical surface at the left side and of a large part of it at the right side as well as the rest of the surfaces are simultaneously seen from a single unit, (TB 5.7, fig. 33, p. 347).

At the ground and second floor the simultaneous exposure of the physical elements constructed at stage one is not retained. Besides, it is only the right part of the cylindrical surface that can be experienced as a continuous element from the Global Scale convex space or the short path units at the right side of the plan, (TB 5.1, fig. 30, 36, p. 338). However, the continuous network of the Global Scale units and overlap units successively synchronises the outer and the inner surfaces.

- **Geometrical properties of spatial articulation**

The Symmetry Global Scale convex space index at the ground floor moves from 1 at stage one and two to 0.80 at stage three, (TB 5.9, p. 349). Therefore, the distribution of Global Scale convex spaces moves from overall symmetry on the BF axis to 'just about symmetry at stage three. At the first floor it changes from overall symmetry to local symmetry. Finally, at the second floor it is characterised by local symmetry throughout the stages.

The Symmetry Global Scale-Unit index at the ground and first floor changes from 1 at stage one and two to 0.52 and 0.86 at stage three, (TB 5.11, p. 349). Therefore the organisation of the Global Scale units moves from overall symmetry to local symmetry, (ground floor) and 'just about' symmetry at the first floor. At the second floor these units are characterised by local symmetry in all stages, (TB 5.11, p. 349).

The Symmetry Spatial-Unit index moves from overall symmetry on the BF axis at the ground and first floor to local symmetry, (Symmetry Spatial-Units index at stage three: 0.50 and 0.58 respectively, TB 5.12, p. 350). At the second floor the spatial units are charaterised by local symmetry throughout the stages.

Finally, the Symmetry Short Path-Unit index at the ground floor moves from 1 at stages one and two to 0.71 at stage three showing that the distribution of the short path units changes from overall symmetry to 'just about' symmetry, (TB 5.13, p. 350). In the rest of the floors the value of this index is much lower showing that there is a weaker pattern of symmetrical distribution of the short path units.

Therefore, from stage one to stage three the organisation of the Global Scale convex spaces, the Global Scale units, the spatial units, and the short path units, retaining 'just about' symmetry or local symmetry becomes a close approximation of the organisation of the first stage.

Spatial experience seems to be regularised through global and local scale information released from symmetrical spatial elements or from locations situated on the co-ordinating axis. Thus, there are symmetrical or almost symmetrical visual fields constructed from the units that are situated on the BF axis, (TB 5.7, fig. 30, 33, 36, p. 347). There are also symmetrical or almost symmetrical visual fields released from units that are symmetrical on this axis, (TB 5.8, fig. 37-38, 39-40, 41-42, 45-46, p. 348).

Analysis shows that apart from a lack of overall symmetry characterising every spatial system, there are certain deviations from symmetry characterising the distribution of the most connected units on the plans. Thus, these units at the ground and first floor at stage three, are not geometrically co-ordinated by the BF axis[37], (TB 5.6, fig. 30, 33, p. 344).

Besides, the distribution of the invariance values of the rest of the units at stage three is not governed by symmetry in any floor. This is shown by the Symmetry iInvariance Value index which is: 0.07 at the ground floor, 0.13 at the first floor and 0.11 at the second floor, (TB 5.15, p. 351). These deviations from the symmetrical pattern seem to compensate for the strong symmetries of the plan. Besides, as it was suggested before, they seem to arouse the keener interest of a viewer who tries to fit these deviations within the overall pattern of symmetry.

37 This observation is not contradicted by what is suggested above, i.e. that it is from the central o-unit that maximum information about the first floor plan is released. This is because one of the most connected units shares one defining side with the central o-unit.

- # L E C O R B U S I E R

- ## V I L L A S A V O I E - ( L H 2 )

- ## DESCRIPTION OF STAGES

- ### STAGE ONE

At stage one there are two Global Scale convex spaces each of which runs at width at the left or at the right side of the ground floor. There is also a Global Scale convex space extending at length at the front of this floor, (TL 5.1, fig. 13, p. 378). At the first floor there is a Global Scale convex space extending at width at the right side and another one at the middle of the plan. There is also a Global Scale convex space stretching at length at the front side of the layout, (TL 5.1, fig. 4, p. 378). The organisation of Global Scale convex spaces at the ground floor is symmetrical on the BF axis. There is no symmetry governing these spaces at the first floor.

Every overlap unit at the ground floor is a Global Scale unit, (TL 5.2, fig. 13, p. 379). These are symmetrically distributed on the BF axis. The Global Scale-Unit index at the first floor is 0.17. Thus, there are very few positions offering large scale visual fields that reach the periphery of the plan. There is no symmetry characterising the organisation of these units, (TL 5.2, fig. 16, p. 379).

The overlap units at this floor cover almost the entire area of the plan situated side by side, (TL 5.4, fig. 16, p. 381). The Symmetry Spatial-Unit index is 0.31, (TL 5.9, p. 388). Thus, there is local symmetry characterising the organisation of the spatial units in terms of shape, size, position and overlap value.

The short path units at the ground floor occupy the central part of the interior space and the four corners of the outside space, (TL 5.5, fig. 13, p. 382). They are symmetrical on the BF axis in terms of shape, size and position. At the first floor the short path map consists of units that are isolated from each other occupying the periphery of the plan, (TL 5.5, fig. 16, p. 382). There is no geometrical co-ordination of these units on any of the axes of the block.

The most connected units at the first floor is the rectilinear unit at the front of the plan. The Invariance Value index of this units is: 0.51, TL 5.10, p. 390). There is no symmetrical distribution of the invariance values of the rest of the units in any of the axes of the block.

- ### STAGE TWO

At stage two the transformation of both floors is based on the addition of the columns, the ramp and a spiral staircase at the centre and the left side of the plan, (TLH2 4.1, fig. 2, 5, p. 284, see figures of Plan analysis). There are also three shapes superimposed at the back and the right side of the ground floor and six shapes superimposed along the periphery of the first floor.

At the ground floor there are two Global Scale convex spaces extending at length at the front side of the ground floor, (TL 5.1, fig. 14, p. 378). There are no changes characterising the configuration of the Global Scale convex spaces at width. At the first floor there are two narrow Global Scale convex spaces extending at width at the middle of the plan and a wider one at its right side, (TL 5.1, fig. 16, p. 378). The configuration of the Global Scale convex spaces at length remains as defined at stage one.

The Global Scale-Unit index at the ground floor is 0.29, (TL 5.8, p. 388). At the first floor this index is: 0.32. Thus, there are few positions providing global scale visual information.

There is a main cluster of overlap units found at the front side of the ground floor and smaller clusters or individual overlap units that are separated from each other, (TL 4.4, fig. 14, p. 381). At the first floor there is a large cluster of overlap units covering the outside space and the right side of the sitting area. There are also smaller clusters and individual overlap units scattered at separate locations, (TL 5.4, fig. 17, p. 381).

The short path units in both floors spread throughout the plans. They occupy different positions sharing none of their defining sides, (TL 5.5, fig. 14, 17, p. 382). Therefore, a complete picture of these layouts is possible through extensive exploration that covers the layout as a whole.

The most connected units at the ground floor is the rectangular unit at the front left side of the plan, (TL 5.6, fig. 14, p. 383). At the first floor the most connected unit is the rectilinear unit situated on the ramp, (TL 5.6, fig. 17, p. 383). The Invariance Value index of the most connected unit at the ground floor is: 0.42, (TL 5.10, p. 390).

There is no symmetry characterising the distribution of the Global Scale convex spaces, the Global Scale units, the short path units, the most connected units and the invariance values in any of the floors[38]. The only exception are the Global Scale convex spaces at the ground floor which are symmetrical on the BF axis.

- **STAGE THREE**

The changes altering the configration of these plans at stage three are about the superimposition of four shapes at the left side and of another one at the right side of the ground floor, (TLH2 4.1, fig. 3, p. 284, see figures of Plan Analysis). There is a large shape superimposed at the first floor extending from the

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38 The organisation of the spatial-units is the only exception. However, the Symmetry Spatial-Unit index shows that the symmetrical pattern is rather weak, (0.11 for the ground floor and 0.10 for the first floor, TL 5.9, p. 388).

back to the centre of the plan. There are also two small shapes superimposed at the left side of the composition and three small shapes aded on the plan, (TLH2 4.1, fig. 6, p. 284).

The Global Scale convex spaces at the ground floor remain as defined at stage two, (TL 5.1, fig. 15, p. 378). There are no changes introduced to the Global Scale units either, (TL 5.2, fig. 15, p. 379). At the first floor one of the narrow Global Scale convex spaces extending at width and the Global Scale convex space extending at length defined at stage two are removed, (TL 5.1, fig. 18, p. 378). The Global Scale-Unit index at this floor is 0.15, (TL 5.8, p. 388). Thus, there are not many positions offering views that extend throughout the plan.

There are no major changes in the configuration of the overlap units at the ground floor, (TL 5.4, fig. 15, p. 381). At the first floor the overlap units occupying the outside space and the right side of the sitting room stay as defined at the previous stage, (TL 5.4, fig. 18, p. 381). In the rest of the plan small clusters or singular overlap units are formed situated inside the enclosed spaces. Therefore, visual information remains to a great extent limited to the scale of a single bounded space.

The short path units spread over the layouts occupying separate positions, (TL 5.5, fig. 15, 18, p. 382). The majority of these units are either overlap units located inside enclosed spaces or bounded spatial units.

The most connected unit at the ground floor remain as defined at stage two, (TL 5.6, fig. 15, p. 383). At the first floor the most connected unit is a small rectangular unit situated inside the enclosed space at the back central part of the layout, (TL 5.6, fig. 18, p. 384). The Invariance Value index of the most connected unit at the ground floor is: 0.40, (TL 5.10, p. 390). At the first floor this index is: 0.22.

Apart from the Global Scale convex spaces at the ground floor which are symmetrical on the BF axis, there is no overall symmetry, 'just about' symmetry or local symmetry governing the organisation of any of the spatial systems in any of the two floors[39].

- **COMPARISON ACROSS STAGES**

- **Spatial properties**

At stage one the interior of the ground floor is seen as a whole from a single position, (TL 5.5, fig. 13, p. 382). However, the inside and the outside space cannot be simultaneously seen from a single spatial unit. At the first floor there are not many positions offering global scale information, (Glocal Scale-Unit

39 The only exception is the spatial units which are characterised by local symmetry on the BF axis. However, similarly to stage two this is a weak pattern of symmetry, (Symmetry Spatial-Unit index: 0.10 and 0.07, TL 5.9, p. 388).

index: 0.17, TL 5.9, p. 388). Besides, the short path units are separated from each other and situated along the periphery of the plan, (TL 5.5, fig. 16, p. 382). Thus, a complete picture of this layout is possible through a large scale observation route. However, there is a constant synchronisation of convex spaces provided from the dense and continuous network of overlap units, (TL 5.4, fig. 416, p. 381).

From stage one to stage three the Global Scale convex spaces at the ground floor stay the same, (TL 5.1, fig. 13-15, p. 388). At first floor the Global Scale convex space running at width and one of the two Global Scale convex spaces extending at length defined at stage two are eliminated, (TL 5.1, fig. 16-18, p. 388). The Global Scale-Unit index remains below 0.29 throughout the stages in both floors, (TL 5.8, p. 388). Therefore, there is a tendency to preserve a small number of views that synchronise opposite sides of the layouts.

From stage two to stage three the large cluster of overlap units covering the interior and the exterior in both floors is also preserved in terms of shape, size and overlap value, (TL 5.4, fig. 13-18, p. 381). All these units at the ground floor and some of these units at the first floor are Global Scale-units, (TL 5.2, fig. 13-18, p. 379).

The configurational properties of the rest of the overlap units change. Thus, they no longer spread throughout the plan covering only a very small area of both interiors. Besides, most of them no longer share their defining sides. They are either situated inside different bounded spaces or they are separated from each by intervening non overlap units. Finally, the distribution of colour, (light purple), shows that the overlap value of these units is low. There is generally no synchronisation of more than two convex spaces.

Therefore, transformation preserves a certain degree of synchronisation of the interior and the exterior, of global and local scale convex spaces and the positions from which this is offered while at the same time eliminates such synchronisation from a large area in both plans.

Analysis showed that each stage retains certain short path units defined at the previous stage in terms of shape, size and position. Nevertheless, there is a large number of new short path units which are introduced along the analytic sequences. These are randomnly distributed on separate positions spreading throughout the plans, (TL 5.5, fig. 14, 15, 17, 18, p. 382). At stage three a large number of these units are located inside bounded spaces.

Therefore, on the one hand certain areas of the plans are revealed from the same locations in all stages. On the other hand the exploration pathways change passing through different units in each stage. Besides, their patterns of relations change as they become situated on different convex spaces that are isolated from each other by boundary walls. Finally, there is no tendency to construct and preserve a specific configuration of the short path in any floor. Thus, transformation creates a long and random exploration route that passes through clearly bounded spaces transmitting a different piece of information each time.

The most connected unit at the ground floor is preserved in all stages, (TL 5.6, fig. 13-15, p. 383) On the other hand, at the first floor the shape, size and position of this unit changes, (TL 5.6, fig. 16-18, p. 383). The Invariance Value index of the most connected units at the ground floor stays above 0.40 in all stages. At the first floor it drops from 0.51 to 0.22. Therefore, it is only at the ground floor that a simultaneous exposure of a large number of units is created and a large number of visual fields retain constant contact with a unit[40]. Finally, it is only at this floor that the above are possible from the same position throughout the stages.

Therefore, the comparative examination of stages shows that the spatial properties that stay invariant during transformation retain the exposure of global scale information and the successive exposure of a number of convex spaces in both floors from specific locations. They also retain the synchronisation of a large number of units that are also invariant characteristics of visual fields from the same positions. On the other hand, there is a general tendency to restrict global scale information, to disconnect convex spaces from each other, to produce a long and random observation route, to restrict the number of units visible from the most connected units as well as the number of visual fields that retain contant connection with these units.

- **Physical properties of spatial articulation**

At stage one the surfaces of the curvilinear volume can be seen at once from a single spatial element, (TL 5.5, fig. 13, p. 382). At the first floor it is only the right and the front sides of the largest volumetric component that can be seen in their entire length from the Global Scale convex spaces extending at these positions, (TL 5.1, fig. 16, p. 378). Besides, there is no single position exposing the external surfaces and the surfaces of the rest of the components at once. Nevertheless, the extensive coverage of this plan by overlap units shows that visual fields constantly construct a successive synchronisation of these surfaces.

At stages two and three the reduction of the Global Scale convex spaces and of the Global Scale-Unit index shows that the number of fields that expose the outer surfaces in full length and connect opposite surfaces from distance are reduced, (TL 5.1, fig. 17, 18, TL 5.8, p. 378). From the areas where the above characteristics are preserved visual fields expose the rows of columns at the ground floor and the right surface of the volume at the first floor.

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40 However, visual synchronisation and invariant information concern only the front area of the plan. At the back visual information is restricted to a small number of units and convex spaces as analysis suggested above.

From these areas the preservation of a dense and continuous network of overlap units synchronises the outer and the inner surfaces in every step, (TL 5.4, fig. 14, 15, 17, 18, p. 381). From the areas where the overlap units are isolated there is synchronisation of surfaces that is limited at the local scale of a single convex space.

Therefore, as the examination of the spatial properties showed these layouts distinguish between areas in which global and local scale physical elements become interrelated and areas in which they are experienced as discontinuous components.

- **Geometrical properties of spatial articulation**

Analysis of the geometrical properties of each stage showed that there is no symmetry governing the distribution of spatial elements in any of the spatial systems examined above[41].

The absence of symmetry in the organisation of the spatial systems results in an absence of regularity in the structure of visual information. There are no symmetrical or repetitive visual fields that can relate spatial elements together independently of the temporal sequence in which these elements are viewed in space.

- **VILLA MEYER (LH3)**

- **DESCRIPTION OF STAGES**

- **STAGE ONE**

At stage one there is a Global Scale conve space extending at width at the left and a Global Scale convex space at the right side of the ground floor. There is also a Global Scale convex space extending at length at the back and another one at the front of the plan, (TL 5.1, fig. 19, p. 378). The Global Scale convex spaces extending at length are symmetrical on the LR axis of the block. Besides, the Global Scale convex space at length at the back of the plan and the Global Scale convex space at width at the right side are symmetrical on the diagonal axis. Thus, there is overall symmetry on the LR axis and local symmetry on the diagonal axis characterising the organisation of these spaces.

At the first floor there is a Global Scale convex space extending at width at the left side of the plan. There are also two Global Scale convex spaces extending at length at the back and the centre of the layout, (TL 5.1, fig. 22, p. 378). The space extending at length at the back and the one extending at

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41 It is only the short path units at the ground floor which are characterised by symmetry on the BF axis at stage one, (TL 5.5, fig. 1, p. 362), and the Global Scale convex spaces at the same floor which exhibits symmetry on the same axis throughout the stages, (TL 5.1 fig. 13-15, p. 358).

width are symmetrical on the diagonal axis of the block. Similarly to the ground floor local symmetry organises the Global Scale convex spaces on this axis.

Almost every spatial unit at the ground floor is a Global Scale unit, (Global Scale-Unit index: 0.88, TL 5.8, p. 388). At the first floor the Global Scale-Unit index is 0.71. Thus, both layouts offer information that extends throughout the plan either at length or at width or at both directions from the majority of spatial locations. The Global Scale units at the ground floor are symmetrical on the LR axis. At the first floor there is no symmetry organising these units in any axis.

The overlap units at the ground floor occupy the left, the right and the front sides of the plan, (TL 5.4, fig. 19, p. 381). At the first floor there is a sequence of units stretching next to the left side and another one extending at length at the centre of the plan, (TL 5.4, fig. 22, p. 381). The spatial units are symmetrical on the LR axis in terms of shape, size and position but not in terms of overlap value.

There are two short path units at the ground floor each of which occupies the right back or the front left corner, (TL 5.5, fig. 19, p. 382). At the first floor there is a short path unit at the back left corner and another one at the outside space, (TL 5.5, fig. 22, p. 382). The geometrical centres of the short path units at the back right corner are covered by the diagonal axis.

The most connected unit at the ground floor is situated at the outside space at front left corner of the plan, (TL 5.6, fig. 19, p. 383). At the first floor the most connected unit is also found at the outside space placed at the left central area of the layout, (TL 5.6, fig. 22, p. 383). The Invariance Value index of the most connected unit at the ground floor is : 0.72, (TL 5.10, p. 390). This index at the first floor is : 0.66. There is no symmetry characterising the arrangement of the invariance values of the rest of the units in both floors.

- **STAGE TWO**

At stage two both floors are transformed by the addition of the columns as well as by the addition of the ramp at the back right corner of the composition, (TLH3 4.1, fig. 2, 5, p. 286, see figures of Plan Analysis). There are also two curvilinear shapes superimposed at the ground floor and two components added at the first floor.

At the ground floor there is one Global Scale convex -space extending at width at the left side and two Global Scale convex spaces extending at width at the right side of the plan, (TL 5.1, fig. 20, p. 378). There is also one Global Scale convex space extending at length at the front side of the plan. At the first floor there are two Global Scale convex spaces running at width at the right side of the plan, (TL 5.1, fig. 23, p. 378). The Global Scale-Unit index at the ground floor is: 0.53, At the first floor this index is: 0.60, (TL 5.8, p. 388).

The overlap units at the ground floor are arranged in clusters each of which occupies a corner of the layout, (TL 5.4, fig. 20, p. 381). At the first floor there is a sequence of overlap units at the left side and cluster of overlap units at the back right side of the layout, (TL 5.4, fig. 23, p. 381). There are very few spatial units that are symmetrical on the LR axis in both floors. These are the units situated on this axis, (TL 5.4, fig. 20, 23, p. 381).

The short path at the ground floor consists of units that are separated from each other occupying the front left and right corners of the plan, (TL 5.5, fig. 20, p. 382). At the first floor the short path units are also separated from each other occupying the back left corner and the right central part of the plan, (TL 5.5, fig. 23, p. 382).

The most connected unit at both floors is situated at the back right part of the layout, (TL 5.6, fig. 20, 23, p. 383). The Invariance Value index of the most connected unit at the ground floor is : 0.37. At the first floor this index is: 0.43, (TL 5.10, p. 390).

The geometrical organisation of the Global Scale convex spaces, the Global Scale units, the spatial units, the short path units, the most connected units and the invariance values at this stage is not governed by overall symmetry, 'just about' symmetry or local symmetry in any of the axes of the composition, (TL 5.1, TL 5.2, TL 5.4, TL 5.5, TL 5.6, fig. 20, 23, p.p. 378, 379, 381, 382, 383).

- **STAGE THREE**

At stage three the transformation of the ground floor is based on the superimposition of a circular shape at the right side of the plan and the addition of a number of partitions at the left side, (TLH4 4.1, fig. 3, p. 286, see figures of Plan Analysis). At the first floor there there are three large shapes and two small ones superimposed at the back of the composition, (TLH4 4.1, fig. 6, p. 286).

The configuration of the Global Scale convex spaces at the ground floor remains as defined at stage two, (TL 5.1, fig. 21, p. 378). At the first floor only one of the two Global Scale convex spaces extending at the right side of the plan at stage two is retained, (TL 5.1, fig. 24, p. 378). The Global Scale-Unit index at the ground floor is 0.33 while at the first floor is 0.05, (TL 5.8, p. 388). Therefore, there are few positions offering information that reaches throughout the plan in both layouts.

At the ground floor there are two linear sequences of overlap units covering the left and the front side of the plan, (TL 5.4, fig. 21, p. 382). At the first floor there is a large cluster of overlap units extending from the outside to the inside space at the left side of the composition. There are also smaller clusters and singular overlap units spreading throughout the layout, (TL 5.4, fig. 24, p. 382). These are separated by intervening boundaries and non overlap units.

The short path at the ground floor consist of units that are separated from each other occupying the front left and right corners and the back central part of the layout, (TL 5.5, fig. 21, p. 382). At the first floor the majority of these units are located inside bounded spaces, (TL 5.5, fig. 24, p. 382). Thus, they are separated from each other by dividing walls.

The most connected unit at the ground floor is retained as defined at the previous stages, (TL 5.6, fig. 21, p. 383). At the first floor the most connected unit is the small rectangular unit inside the enclosed space at the right side of the plan, (TL 5.6, fig. 24, p. 383). The Invariance Value index of the most connectd unit at the ground floor is : 0.28, (TL 5.10, p. 390). At the first floor this index is: 0.22.

In all the spatial systems examined above there is no symmetrical distribution of the spatial elements in any axis of the block in any of the two floors, (TL 5.1, TL 5.2, TL 5.4, TL 5.5, TL 5.6, fig. 19, 24, p.p. 378, 379, 381, 382, 383).

- **EXAMINATION ACROSS STAGES**

- **Spatial properties**

At stage one there is an extensive coverage of the ground and first floor by Global Scale convex spaces, and Global Scale units showing that the layouts offer global scale views from almost every location, (TL 5.1, TL 5.2, fig. 19, 22, p. 378). However, there is not a single unit revealing the interiors as wholes, (TL 5.5, fig. 19, 22, p. 382). Besides, the short path units belong to different Global Scale convex spaces. Thus, visual fields produced from each unit are different from each other.

In the following stages the Global Scale convex spaces extending next to the left, the right and the front sides of the ground floor, and next to the right side of the first floor are preserved[42], (TL 5.1, fig. 19-21, p. 378). Therefore, certain patterns of global scale visual information and the positions from which this is offered are retained.

At the ground floor the Global Scale units resulting from the overlap amongst the Global Scale convex spaces that are preserved remain the same, (TL 5.2, fig. 20, 21, p. 379). The Global Scale-Unit index at this floor moves from 0.88 to 0.33. At the first floor it drops from 0.71 to 0.05. Therefore, it is only at the ground floor that a large number of visual fields that reach throughout the plan is retained.

At the ground floor the distribution of overlap units in two linear sequences along the left and the front side of the plan is preserved, (TL 5.4, fig. 19-21, p. 381). From stage one to stage three the number, the

42 From stage one to stage three the size of the Global Scale convex spaces situated next to the left and the right sides of the ground and next to the right side of the first floor changes. However, there is always a Global Scale convex space at these positions throughout the stages.

shape and size of the overlap units situated at the left side of the first floor change, (TL 5.4, fig. 22-24, p. 381). However, their distribution side by side along the left surface of the layout stays the same. Therefore, a constant and successive synchronisation of convex spaces, of the interior and the exterior and the areas from which this is offered are retained in both floors. At the ground floor some of the overlap units remain Global Local Scale units throughout the stages. Thus, from these units there is a synchronisation between global and local scale relations.

At the other parts of both floors the configuration of the overlap unit map changes to form clusters of small units separated from each other by non overlap units and enclosing walls. Therefore, the patterns of synchronisation of convex spaces in this area change in a way that only sub-complexes of two or three small scale convex spaces are simultaneously seen[43]. Besides, as non overlap units separate one cluster from the other the successive synchronisation of convex spaces is often interrupted by visual information about a single convex space. Finally, the separation of clusters by boundary walls shows that visual fields change every time one steps inside a different convex space.

At the ground floor each stage preserves certain short path units defined at the previous stage, (TL 5.5, fig. 20, 21, p. 382). On the other hand, the short path units at the first floor are different in each stage, (TL 5.5, fig. 23, 24, p. 382). Therefore, while at the former the shortest route retains certain parts, in the latter it develops in a completely different way throughout the stages.

Besides, there is an increased number of short path units that spread in a random arrangements throughout the plans. These units belong to different convex spaces and are separated from each other by boundary walls. In other words, there is an increased emphasis in extending the observation pathways. Besides, there is an increased emphasis in breaking down the information received during movement from one unit to the other the scale of smaller and different convex spaces. Finally, there is a tendency to create a random and different observation route in each floor.

The most connected unit at both floors changes from stage to stage in terms of shape, size and position, (TL 5.6, fig. 19-24, p. 383). Thus, it is only at the ground floor that the positions synchronising the largest number of units and featuring in the largest number of visual fields at the ground floor are retained.

However, the Invariance Value index of the most connected unit moves from 0.72 at stage one to 0.37 at stage three at the ground floor and from 0.66 to 0.22 at the first floor, (TL 5.10, p. 390). Thus, there is a tendency to reduce the degree of simultaneous synchronisation offered from these units as well as the number of visual fields that retain constant contact with them.

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43 The low number of the convex spaces that are synchronised is indicated by the low overlap value of the overlap units.

To summarise, transformation distinguishes between areas in which certain spatial properties are preserved and areas in which they change. From the former there is global scale information, a successive and a simultaneous synchronisation of global and local scale relations and visual information that remains invariant over a certain length of time. From the latter, global scale information is eliminated and the successive synchronisation of convex spaces is reduced to the level of few, small scale and bounded convex spaces. Finally, the simultaneous synchronisation of spatial relations as well as the degree to which certain units remain invariant characteristics of visual fields is also reduced.

- **Physical properties of spatial articulation**

At stage one all surfaces apart from the front outer surface at the first floor are visible in their entire length from the Global Scale convex spaces extending next to them, (TL 5.1, fig. 19, 22, p. 378). The high value of the Global Scale-Unit index shows that visual fields constantly synchronise opposite surfaces of the volume, (TL 5.8, p. 388). However, there is no single position from which all physical elements are simultaneously seen, (TL 5.5, fig.19, 22, p. 382). To built a complete picture of these elements one has to move occupying separate short path units.

At stages two and three the preservation of the Global Scale convex spaces extending next to the right, the left and the front surfaces at the ground floor results in a full exposure of these surfaces, (TL 5.1, fig. 20, 21, p. 378). Further, a large part of the back surface is visible from the convex space extending at length at the back of the composition. Besides, the preservation of the sequences of overlap units situated along the left and the front sides results in a successive synchronisation of the outer surfaces, the surfaces of the void and the inner surfaces, (TL 5.4, fig. 20, 21, p. 381).

At the first floor transformation retains only the right side of the block as a physically continuous element, (TL 5.1, fig. 23, 24, p. 378). However, a large part of the left surface is seen from the convex space extending next to it, (TL 5.1, fig. 23, 24, p. 378). The reduction of the Global Scale-Unit index at this floor reduces the number of visual fields that connect the opposite surfaces of the volume, (TL 5.8, p. 388). Besides, the clusters of overlap units scattered in between non overlap units and enclosing boundaries show that visual synchronisation of the outer and the inner surfaces first is often confined to the scale of bounded spaces and second it gapped by the intervention of non overlapping units and dividing surfaces.

Therefore, analysis shows that the preservation and obliteration of spatial patterns carries with it a preservation and obliteration of physical patterns. The layouts distinguish between areas where the continuity of the outer surfaces is immediately exposed and areas where these surfaces are experienced as discontinuous components. It also distinguishes between parts where the outer and the inner surfaces become gradually interrelated and surfaces from which they are seen as disconnected. At the first floor disconnection of physical relations is more extensively experienced as the layout is broken up into a set of clearly demarcated spatial enclosures.

- **Geometrical properties of spatial articulation.**

Analysis suggested that there is no symmetry characterising the organisation of any of the spatial systems in either of the floors in any stage[44].

In this respect, there is no geometrical pattern adding geometrical relations to spaces. Spatial experience unfolds as a sequence of spatial events that cannot jump out of their spatial and temporal location to be connected with each other according to a regular pattern.

- **V I L L A B A I Z E A U - ( L H 4 )**

- **DESCRIPTION OF STAGES**

- **STAGE ONE**

At stage one the ground floor plan is covered by two Global Scale convex spaces extending from left to right, (TL 5.1, fig. 25, p. 378). At the first floor there is a single Global Scale convex space extending along this direction, (TL 5.1, fig. 28, p. 378). There is also a Global Scale convex space extending from back to front at the left and another one at the right side of the plan. The second floor is covered as a whole by a single convex space, (TL 5.1, fig. 31, p. 378). Finally, the third floor is covered by two Global Scale convex spaces stretching from back to front and a single Global Scale convex space extending from left to right, (TL 5.1, fig. 34, p. 378).

The Global Scale units at the ground floor cover almost the entire area of the plan, (TL 5.2, fig. 25, p. 379). The Global Scale-Unit index is: 0.42[45], (TL 5.8, p. 388). At the second and third floor the Global Scale units cover the layouts as wholes, (TL 5.2, fig. 31, 34, p. 379). Finally, at the first floor they also cover a large area of the plan, (TL4 5.2, fig. 28, p. 379). The Global Scale-Unit index at this floor is: 0.80, (TL 5.8, p. 388).

At the ground floor there are two overlap units situated at separate positions, (TL 5.4, fig. 25, p. 381). At the first floor there is a cluster of overlap units extending from the front left corner to the centre of the

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44 The only exceptions are the Global Scale convex spaces and the Global Scale units at the ground floor and the Global Scale units at the first floor at stage one. As it was suggested in the description of stage one the Global Scale units at both floors exhibit overall symmetry on the LR axis, (TL 5.2, fig. 19, 22). The Global Scale convex spaces at the ground floor are characterised by local symmetry on the diagonal axis.

45 The low value of this index is determined by the number of the spatial units which is considerably larger than the number of the Global Scale units. However, the latter cover the largest area of the layout.

plan and two individual overlap units situated in distance from each other, (TL 5.4, fig. 28, p. 381). Finally, at the third floor there are two overlap units sharing a defining side, (TL 5.4, fig. 34, p. 381).

The short path at the ground floor consists of two units each of which is situated at the back left or at the front right side of the plan, (TL 5.5, fig. 25, p. 382). At the first floor there are three short path units at the back left side of the plan as well as a single unit located in front of the curvilinear volume that projects into the terrace, (TL 5.5, fig. 28, p. 382).

At the third floor there are two short path units placed side by side, (TL 5.5, fig. 34, p. 382). The one at the left exposes the interior while the one at the right the exterior. Therefore, the layout is instantly seen as a whole from the common side of these units.

The most connected unit at the ground floor is the trapezoidal unit at the back right and the rectangular unit at the front right corner of the plan, (TL 5.6, fig. 25, p. 383). At the first floor the most connected unit is the rectangular unit at the left central part of the plan, (TL 5.6, fig. 28, p. 383). At the third floor the most connected units are the two units situated side by side, (TL 5.6, fig. 34, p. 383).

The Invariance Value index of the most connected unit at the ground floor is: 0.42, (TL 5.10, p. 390). At the first and third floor this index is: 0.53 and 0.66. Thus, there is a large number of spatial units that retain visual connection with a single unit in all plans.

The distribution of the Global Scale convex spaces, the Global Scale units, the spatial units, the short path units, the most connected units and the invariance values is not characterised by overall symmetry, 'just about' symmetry' or local symmetry in any of these floors, (TL 5.1, TL 5.2, TL 5.4, TL 5.5, TL 5.6, fig. 25, 28, 34, p.p. 378, 379, 381, 382, 383).

- **STAGE TWO**

At stage two the ground floor changes through the superimposition of four shapes along the periphery of the plan and the addition of two staircases at the left side of the composition, (TLH4 4.1, fig. 2, p. 288, see figures of Plan Analysis). At the first floor, second and third floor a stairacse is added at the central left side of the plans, (TLH4 4.1, fig. 5, 8, 11, p. 288). At the first floor there are six shapes superimposed along the right side of the plan and another one superimposed on the curvilinear volume projecting towards the terrace, (TLH4 4.1, fig. 5, p. 288). At the second floor three shapes are superimposed at the left back side of the plan. The four shapes superimposed at the right side of the first floor extend in height to occupy the right side of this floor. There is also a void introduced at the right front side of this floor, (TLH4 4.1, fig. 8, p. 288). Finally, at the third floor a void is added at the front left side of the composition, (TLH4 4.1, fig. 8, p. 288).

At the ground floor there is a Global Scale convex space extending from left to right at the back and another one at the front of the plan, (TL 5.1, fig. 26, p. 378). At the first floor there is one narrow Global Scale convex space running from left to right, (TL 5.1, fig. 29, p. 378). There is also a Global Scale convex space extending from back to front at the left side of the plan. At the second floor there is a Global Scale convex space extending from left to right at the front and a Global Scale convex space running from back to front at the centre of the plan, (TL 5.1, fig. 32, p. 378). Finally, the configuration of the Global Scale convex spaces at the third floor remains as defined stage one, apart from the elimination of the Global Scale convex space extending from back to front at the left side of the plan, (TL 5.1, fig. 35, p. 378).

The Global Scale units occupy a small part of the layout in all plans, (TL 5.2, fig. 26, 29, 32, 35, p. 379). The Global Scale-Unit index at the ground floor is 0.21. At the first, second and third floor this index is: 0.25, 0.33 and 0.26 respectively, (TL 5.8, p. 388). Therefore, in the majority of the plans there are not many visual field synchronising the outer sides of the volume.

At the ground floor there is a cluster of overlap units situated at the front part of the interior and an overlap unit located at the front right side of the layout, (TL 5.4, fig. 26, p. 381). At the first floor there is a cluster of overlap units at the central and the front left side of the plan and individual overlap units separated from each other by non overlapping units, (TL 5.4, fig. 29, p. 381). At the second and third floor there is a cluster of overlap units occupying the front central part of the plan, (TL 5.1, fig. 32, 35, p. 378).

The short path at the ground floor consists of a unit at the front right side of the plan, of two groups of units arranged in a linear sequence and of three spatial units at the back of the layout , (TL 5.5, fig. 29, p. 382). At the first floor the short path units spread from the back to the front situated on the one or on the other side of the BF axis, (TL 5.5, fig. 29, p. 382). Therefore, the layout is seen through movement that progresses from the back to the front.

At the second floor the short path map also consists of isolated units that spread from the back to the front situated mainly at the left and the front left area of the plan, (TL 5.5, fig. 32, p. 382). The spaces at the right side are double height spaces accessible only from the first floor. Therefore, even when the entire layout is traversed it is not possible to see it as a whole.

At the third floor the short path units are arranged in a linear sequence at the right side of the BF axis, (TL 5.5, fig. 35, p. 382). The front left part of the layout and the outside space can be instantly seen from the left defining line of the unit situated in the outside space. Nevertheless, the back left side of the layout is not accessible from this floor.

The most connected unit at the ground floor is the unit situated at the front right corner of the interior space, (TL 5.6, fig. 26, p. 383). At the first floor this unit is the square unit situated at the left side of the plan, (TL 5.6, fig. 29, p. 383). At the second and third floor the most connected unit is the unit placed on the right side of the BF axis at the front of the plan, (TL 5.6, fig. 35, p. 383).

The Invariance Value index of the most connected unit at the ground floor is: 0.42, (TL 5.10, p. 390). At the first , the second and the third floor this index is 0.30, 0.42 and 0.65 respectively. Therefore, there is a considerable number of units that are 'seen' from the most connected unit and a considerable number of visual fields that 'see' this unit.

Similarly to stage one, there is no overall symmetry characterising the organisation of the Global Scale convex spaces, the Global Scale units, the spatial units, the short path units, the most connected units and the invariance values in any floor, (TL 5.1, TL 5.2, TL 5.4, TL 5.5, TL 5.6, fig. 26, 29, 32, 35, p.p. 378, 379, 381, 282, 283).

- **STAGE THREE**

At stage three the superimposed shape defined at the back of the ground floor at stage two, (see figures of Plan AnalysisTLH4 4.1, fig. 2, p. 288), is transformed by the superimposition of three shapes, (see figures of PLan Analysis, TLH4 4.1, fig. 3, p. 288). The shape superimposed at the left side is also changed by the superimposition of three shapes. Finally, the shape at the right side changes by the superimposition of two shapes.

At the first floor there are two small shapes superimposed on the second shape from the back of the composition, (TLH4 4.1, fig. 6, p. 288). There are also three small shapes superimposed on the curvilinear shape that projects towards the terrace. At the second floor there are three shapes each of which is superimposed on one of the three shapes defined at the left back side of the plan at stage two, (TLH4 4.1, fig. 8, 9, p. 288). Finally, at the third floor three mezanines are added inside the shapes occuppying the back left corner of the plan, (TLH4 4.1, fig. 12, p. 288).

The Global Scale convex space defined at the back of the ground floor plan at stage two is removed, (TL 5.1, fig. 27, p. 378). In the rest of the floors the configuration of the GS c-space map is preserved as defined at stage two, (TL 5.1, fig. 30, 33, 36, p. 378).

There are very few changes introduced to the configuration of the overlap units and the Global Scale units map in all floors, (TL 5.2, fig. TL 5.4, fig. 27, 30, 33, 36, p. 379). Thus, the properties of these maps remain as described at the previous stage. The Gloabl Scale-Unit index at the ground floor is: 0.06. At the first floor this index is 0.20. At the second floor it is 0.29. Finally, at the third floor it is 0.22. Therefore, there are very few visual fields that reach throughout these plans.

The configuration of the short path units remains also as defined at the previous stage, (TL 5.5, fig. 27, 30, 33, 36, p. 382). The only difference seems to be the increase in the number of spatial units that are defined by enclosing boundaries at the ground, first and second floor. The experience of these floors remains one of linear progression covering the layouts from back to front.

The most connected units remain also as defined at stage two, (TL 5.6, fig. 27, 30, 33, 36, p. 383). The Invariance Value index at the ground floor is 0.20. At the first floor it is 0.24. Finally at the second and third floor this index is 0.37 and 0.57 respectively. Thus, it is only at the second and third floor that a considerable number of spatial units are 'seen' from the most connected units as well as a considerable number of visual fields retain constant connection with these units.

There is no overall symmetry, 'just about' symmetry or local symmetry organising any of the spatial systems at this stage, (TL 5.1, TL 5.2, TL5.4, TL 5.5, TL 5.6, fig. 27, 30, 33, 36, p.p. 378, 379, 381, 382, 383).

- **COMPARISON ACROSS STAGES**

- **Spatial properties**

At stage one all layouts are completely covered by Global Scale convex spaces and Global Scale units, (TL 5.1, TL 5.2, fig. 2, 28, 31, 34, p. 378). However, apart from the second floor which is covered as a whole by a single Global Scale convex space it is only the third floor that is seen instantly from the common line of the two short path units, (TL 5.5, fig. 34, p. 383). The ground and the first floor are seen as wholes from separate positions, (TL 5.5, fig. 25, 28, p. 383).

In the following stages the Global Scale convex spaces extending at the left side of the first floor and the right side of the third floor are preserved, (TL 5.1, fig. 4, 5, 6, 18-30, 34-36, p. 378). The Global Scale convex spaces extending at the front of the ground and the second floor are also retained, (TL 5.1, fig. 25-27, 32, 33, p. 378). Finally, the Global Scale convex spaces extending from left to right at the second and third floor and from back to front at the third floor stay the same. Therefore, certain patterns of global scale information are retained. However, apart from the second floor these spaces rarely cover the interior situated mainly in the outside space. Thus, there seems to be a tendency to eliminate global scale information in the interior of these layouts.

This seems to be reaffirmed by the Global Scale-Unit index which at stage three drops below 0.29 in all floors, (TL 5.8, p. 388). Therefore, transformation reduces the number of visual fields that extend throughout the plan in relation to the total number of visual fields in these layouts.

From stage one to stage three the overlap units situated at the outside space at the first floor remain the same in terms of shape, size, position and side by side distribution, (TL 5.4, fig. 28-30, p. 381). Some of these units are Global Scale units. Therefore, the patterns of interconnections amongst certain global and local scale relations are preserved. Besides from stage two to stage three a large number of overlap units remain the same.

However, the larger part of all plans incorporates an increasing number of overlap units some of which are gathered in large clusters while others are isolated units occupying separate positions on the plans, (TL 5.4, fig. 25-36, p. 381). The majority of the these units synchronise two to three convex spaces. Therefore, there is a tendency to reduce the levels of synchronisation amongst convex spaces.

The number of the short path units is also increased along the analytic sequences, (TL 5.5, fig. 25-36, p. 382). At the ground, first and second floor these units form a spine that spreads from the back to the front, (TL 5.5, fig. 26, 27, 29, 30, 32, 33, p. 382). Therefore, transformation emphasises the development of a specific global scale observation route in the form of a linear progression .

At the second and third floor a large part of the layouts remains hidden from sight. This is the right part of the second floor and the back left part of the third floor consisting of double height spaces that are accessible from the floor below. The spatial volumes of the two levels interlock at these areas requiring movement that goes up and down these floors to understand how the horizontal layering of the house is organised.

From stage one to stage three the most connected units at the first and third floor stay the same in terms of position on the plans, (TL 5.6, fig. 28-30, 34-36, p. 383). Further, from stage two to stage three the most connected units stay the same in terms of shape, size and position on the plan in all floors, (TL 5.6, fig. 25-36, p. 383). However, the Invariance-Value index at the ground floor drops from 0.42 at stage one to 0.20 at stage three. At the first floor it moves from 0.53 at stage one to 0.24. At the second floor it changes from 1 to 0.37. Finally, at the third floor the i-value drops from 0.66 to 0.57.

Therefore, it is only at the third floor that a large number of units are seen from a single location as well as a large number of visual fields provide information about this location. Nevertheless, visual synchronisation in this floor exposes only the front left and the right side of the plan. The examination of the invariance values reaffirms what the other factors suggested, i.e. experience of these layouts develops gradually through movement that spreads throughout the house along the horizontal and the vertical direction. Visual fields are rich in global scale information only from the outside. In the interior they are often disconnected confined inside different bounded spaces.

- **Physical properties of spatial articulation**

At stage one the curvilinear element defining the interior space at the ground floor is seen as a single spatial volume from the unit stretching from its back to its front side, (TL 5.5, fig. 25, p. 378). At the second floor the block is seen at once from the single convex space that covers it as a whole, (TL 5.1,

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